AD-A239 290

... MENTATION PAGE

Form Approved
OMB No. 0704-0188

...estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, ...g and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this ...g this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson ... to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

REPORT DATE 16 Nov 90	3. REPORT TYPE AND DATES COVERED July - Nov 90
4. TITLE AND SUBTITLE Technology Insertion (TI)/Industrial Process Improvement (IP) Task Order No. 14 Contract Summary Report/Quick Fix Plan for SA-ALC/MAEPNC (Cleaning)	5. FUNDING NUMBERS Contract
6. AUTHOR(S) McDonnell Douglas Missile Systems Company	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) McDonnell Douglas Missile Systems Company St. Louis, Missouri 63166	8. PERFORMING ORGANIZATION REPORT NUMBER F33600-88-D-0567
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) HQ AFLC/LGME WPAFB OH 45433	10. SPONSORING/MONITORING AGENCY REPORT NUMBER F33600-88-D-0567

DTIC
ELECTE
AUG 0 3 1991
S C D

11. SUPPLEMENTARY NOTES

Prepared in cooperation with SA-ALC & HQ AFLC.

12a. DISTRIBUTION/AVAILABILITY STATEMENT Distribution Statement A	12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

This Technology Insertion (TI)/Industrial Process Improvement (IPI) Summary Report for SA-ALC (T.O. 14) ~~. This document~~ contains Focus Study and Quick Fix Recommendations for ~~4~~ (one) Resource Control Centers (RCC's). These RCC's are: MAEPNC (Engine Cleaning). It Also includes Simulation Modeling for this RCC.

91-06876

91 8 05 047

14. SUBJECT TERMS Chemical Cleaning, AFLC	15. NUMBER OF PAGES 53
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unclassified

INDUSTRIAL PROCESS IMPROVEMENT ENGINEERING SERVICES PROCESS CHARACTERIZATION TASK ORDER NO. 14

A-1

VOLUME V
SA-ALC

CONTRACT SUMMARY REPORT
16 NOVEMBER 1990

CONTRACT NO. F33600-88-D-0567
CDRL SEQUENCE NO. 14A008

MCDONNELL DOUGLAS

McDonnell Douglas Missile Systems Company
St. Louis, Missouri 63166-0516 (314) 232-0232

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

TASK ORDER NO. 14
PROCESS CHARACTERIZATION

EXECUTIVE SUMMARY

MDMSC's work under Task Order No. 14 was conducted at SA-ALC from 16 July 1990 through 16 November 1990. As called for in the SOW, a UDOS 2.0 model of MAEPNC (Automated Cleaning Line) was constructed and a detailed engineering assessment of the Resource Control Center (RCC) was conducted. As a result, MDMSC was able to recommend three process improvements as Quick Fixes (QFs) (requiring little or no capital investment) with a first year savings potential of $1,077,425 and 2400 square feet of floor space. MDMSC also recommended one focus study with potential annual savings of $657,000 realized by eliminating approximately 267 tons of hazardous waste each year. This focus study will require additional capital investment and man hour expenditures to complete, and will pay for itself in less than four years. Five additional observations were made which include process improvement recommendations but which could not be adequately quantified for presentation as QF/FSs.

The simulation model was completed on schedule and was used to quantify the results of MDMSC's recommendations. In addition, a second model was developed for the secondary processes not called out in the Task Order No. 14 SOW. This was at no additional cost to SA-ALC. MDMSC has provided over-the-shoulder and formal classroom training to interested members of the MA engineering community in the use and development of the Universal Depot Overhaul Simulator (UDOS) 2.0 model. This training was not a contractual requirement but was considered important to long term program success.

MDMSC's assessment of MAEPNC revealed a number of positive factors. Production management is involved and interested in implementing new ideas. A QP4 team has been organized in the area and is addressing process problems.

There are some areas that are weaker than others, however, and these have been identified. A detailed comparison between MAE and seven major commercial airline repair centers showed that the type and level of support received by MAEPNC falls short of the commercial environment. Scheduling and planning were particularly noted. These areas are a reflection of the priority placed on Scheduling throughout MAE.

MDMSC did not specifically address wartime surge requirements, but did do a capacity analysis of the automated cleaning line. This study, performed using the UDOS 2.0 model, indicated that the automated line can support workloads 200 - 300% higher than the current level without significant impact on flow time, inventory, or process quality. MAEPNC is currently meeting 100% of its production requirements.

The chemical-dip cleaning processes used in MAEPNC are rapidly becoming obsolete as environmental regulations are stiffened. The line generates an average 400 tons of chemical waste and 2.65 million gallons of contaminated rinse water annually. The cost of treating/disposing of this waste stream is an estimated $985,000 per year and can be expected to grow in the future. MDMSC has recommended a major redesign of the cleaning process, using the latest off-the-shelf, environmentally friendly, cleaning technologies. This process has been tested on sample parts provided by MAEPNC and the results provided to SA-ALC engineers to document MDMSC's conclusions.

8.0 INTRODUCTION

This report summarizes MDMSC's process characterization of the jet engine cleaning process(es) as performed in MAEPNC at the San Antonio Air Logistics Center (SA-ALC), Kelly AFB, Texas. This process characterization was performed in accordance with the applicable general Statement of Work (SOW), the Task Order No. 14 SOW, and the MDMSC Task Order No. 14 proposal.

Process performance data was collected by MDMSC engineers and input to the UDOS 2.0 depot simulation model developed under Task Order No. 1 of the Air Force Industrial Process Improvement Program. This simulation model was validated in accordance with the applicable Acceptance Test Procedure. The model was used to analyze the current As-Is production baseline in MAEPNC and evaluate the impact of proposed changes. This analysis included the identification of critical resource constraints and areas of potential improvement.

In addition to the simulation work, MDMSC performed an engineering assessment of the current operations and resources within MAEPNC. The MDMSC on-site engineering staff was supported in this effort by the following specialists:

- One human factors expert from the Douglas Aircraft Company (DAC)
- One chemical engineer from MDMSC
- One F100 engine maintenance specialist from the McDonnell Aircraft Company (MCAIR)
- One commercial aircraft maintenance expert from Embry-Riddle Aeronautical University (ERAU)

The on-site team consisted of three industrial engineers, one mechanical engineer, and one computer simulation specialist.

The original SOW required MDMSC to simulate only the automated cleaning line in MAEPNC. MDMSC engineers determined that, while the automated line could be easily modeled using UDOS 2.0, its low utilization and minimal process variation made it a poor candidate for experimentation. In an attempt to increase the SA-ALC satisfaction with the task order, MDMSC elected to model the secondary cleaning processes in MAEPNC as well. This second model was successfully developed and validated, but the schedule disruption caused by the SA-ALC reorganization (which occurred on 1 October 1990) left MAEPNC Production management unable to support the validation/brainstorming effort until very late in the task order period of performance. As a result, MDMSC was unable to perform any experimentation using the secondary process model. This model has been delivered under this contract, however, and can easily be used by SA-ALC engineers to support their own work. A full set of Taguchi-based experiments was conducted using the automated cleaning line model.

During the performance of this task order, SA-ALC was reorganized, with new office symbols assigned to many areas. Because the old office symbols are called out in the Task Order No. 14 SOW and proposal, MDMSC has elected to continue their use. The division previously known as MAE is now designated LPP, while MAEPNC is now LPPPNI.

8.1 RESOURCE CONTROL CENTER ASSESSMENT

8.1.1 MAEPNC

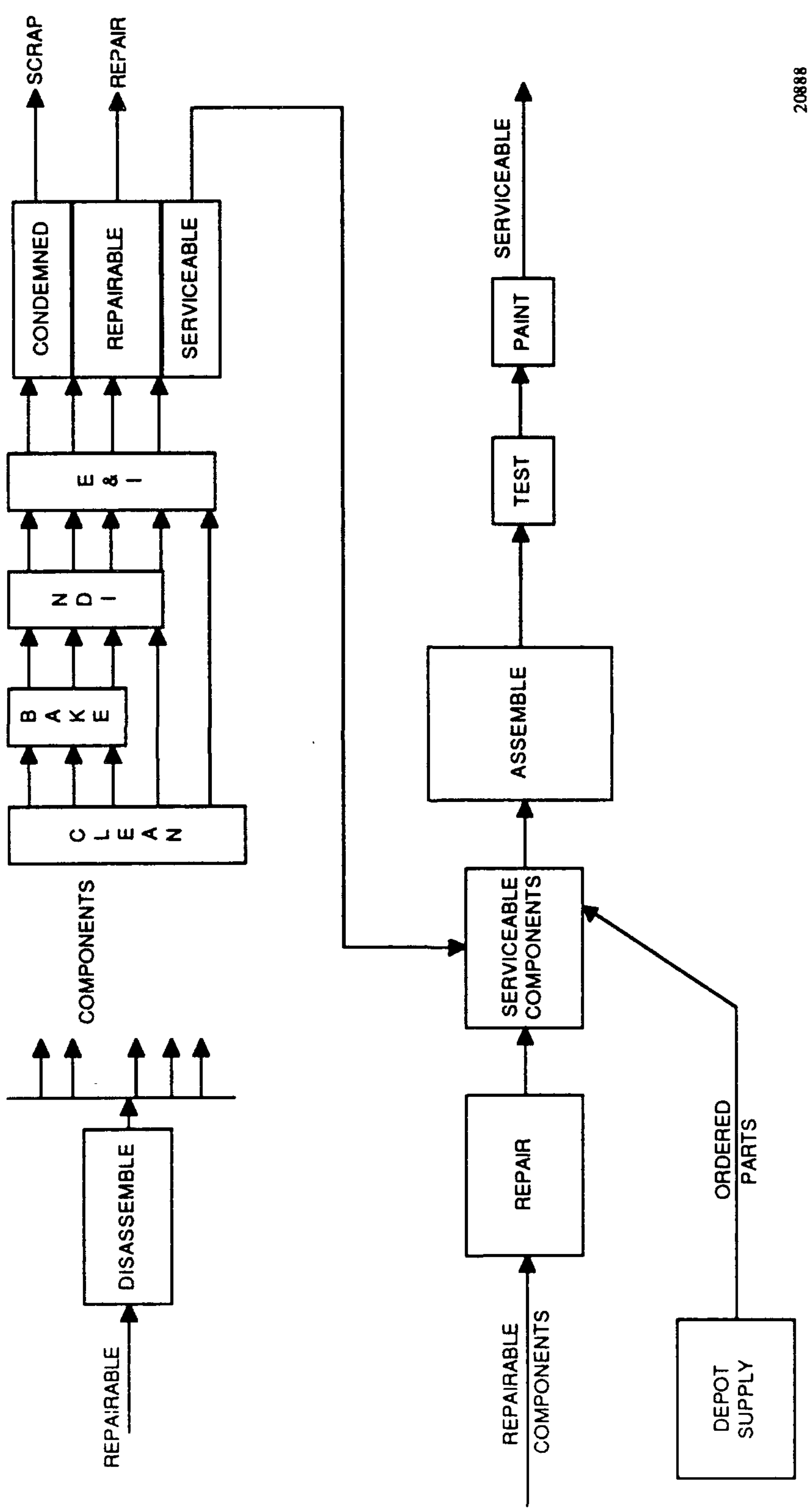
8.1.1.1 Description of Current Operations

MAEPNC currently cleans 100 - 150 thousand engine parts per month, supporting the overhaul of the TF39, T56 and F100/200 engines. These parts are cleaned prior to routing to inspection or repair. The generic flow through the entire engine overhaul process is illustrated in Figure 8.1.1.1-1.

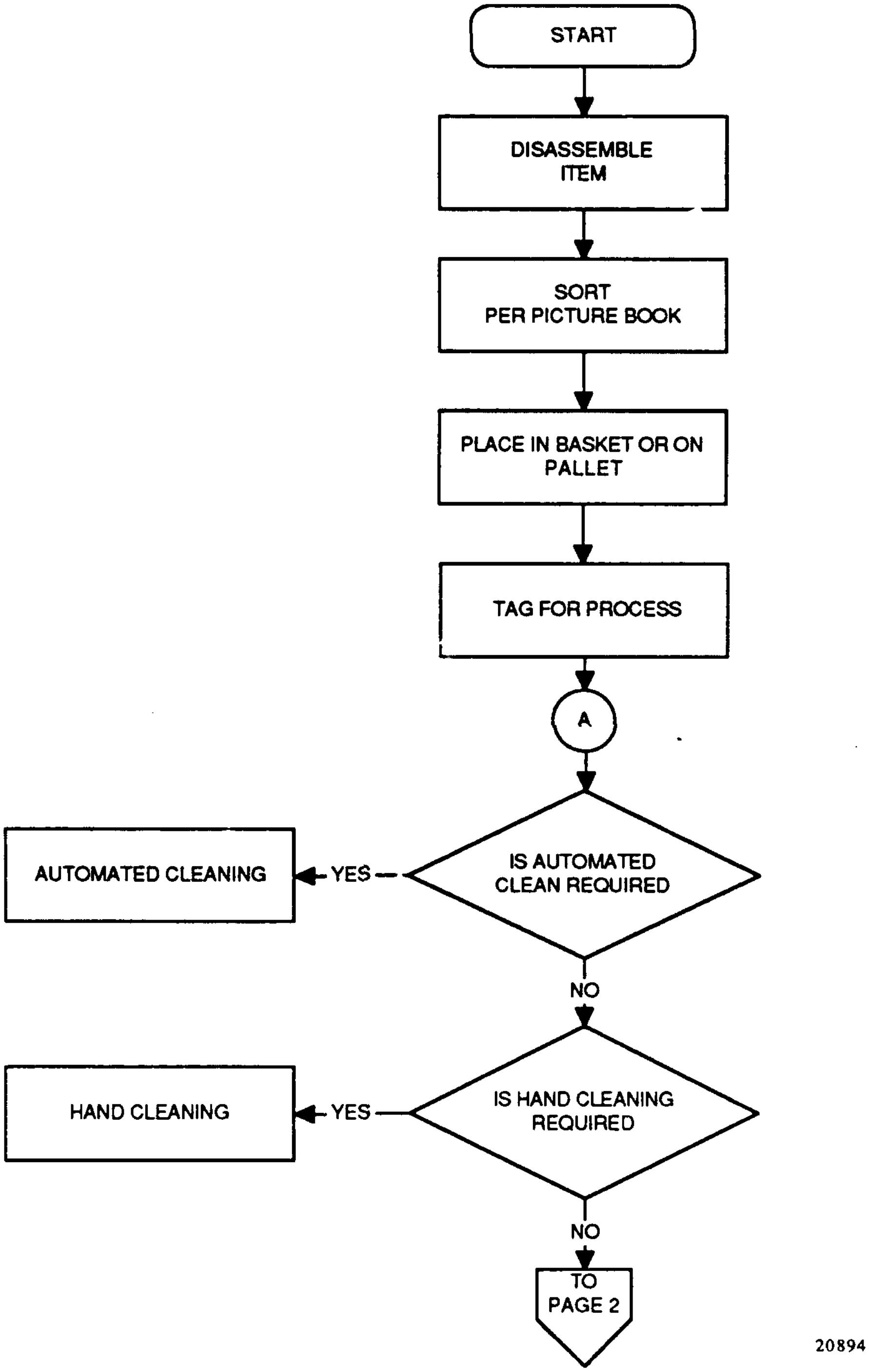
Figure 8.1.1.1-2 illustrates the generic flow of parts through the MAEPNC cleaning process. The parts are routed into the MAEPNC automated cleaning line from disassembly. The TF39 and T56 and a small number of F100/200 parts are cleaned in the automatic line. The bulk of the F100/200 workload must be hand cleaned, however. This situation leaves the automated line, (which was designed for a larger J79 workload almost 20 years ago) under-utilized, while the hand cleaning line is relatively busy. MDMSC's recommendations regarding this excess capacity (supported by UDOS model experimentation in Paragraph 8.2) are described in Paragraph 8.3.2 of this report and Paragraph 8.1.3 of the Task Order No. 14 Quick Fix Plan.

After passing through the automated cleaning line, 93% of the parts require additional cleaning, (mechanical vibration blasting or by hand) before they can be routed to inspection processes. The capacity of the mechanical cleaning process(es) are less than that of the automated line, causing a periodic buildup of Work In Process (WIP) inventory at the end of the automated cleaning line. The real impact of this cannot be evaluated, however, without a capacity study of the entire engine line(s). <u>MDMSC recommends this be performed before additional RCCs within the process are characterized</u>.

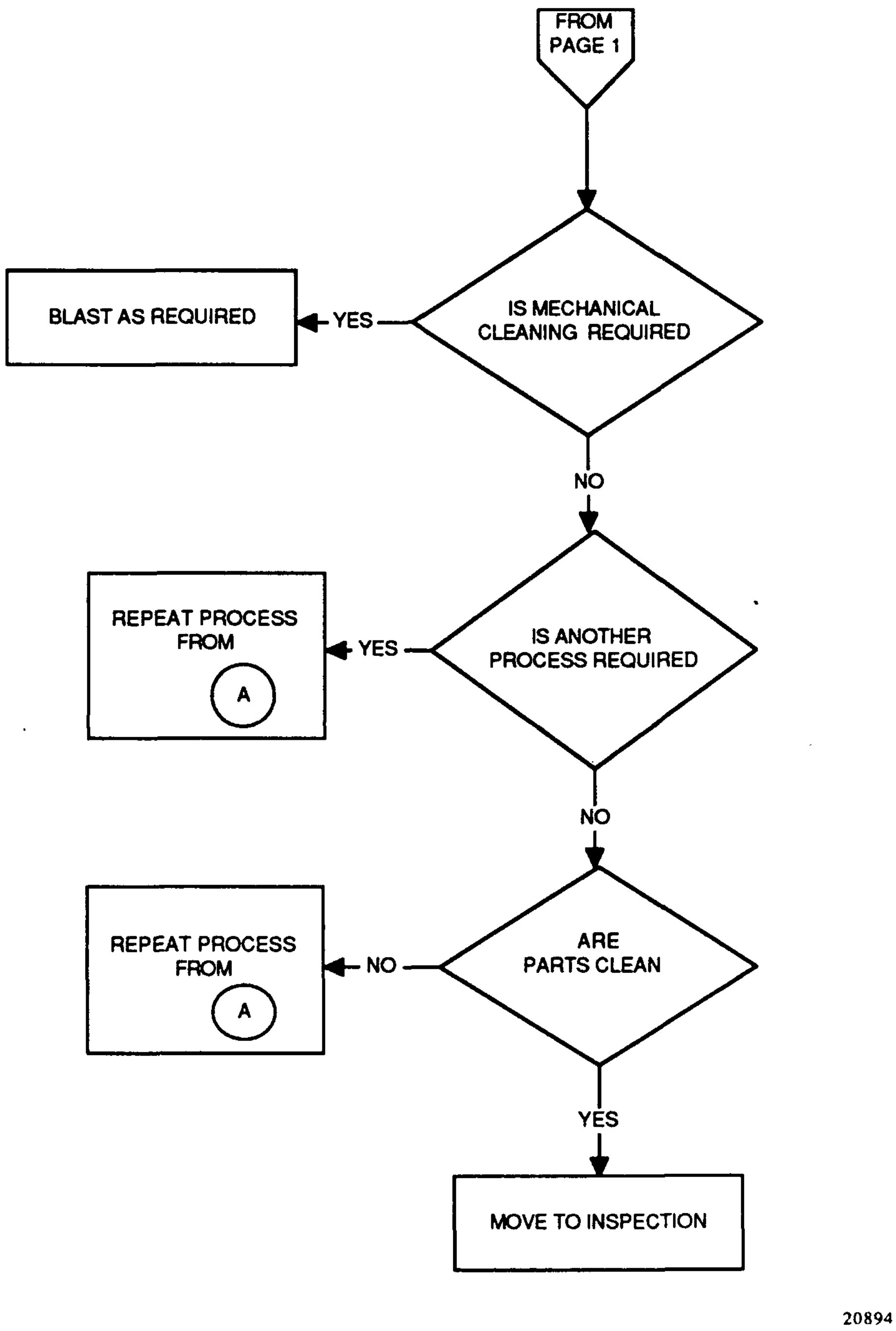
The actual value of the automated cleaning line is questionable. It <u>does</u> facilitate the mechanical cleaning but <u>does not</u> actually clean many parts itself. It also occupies approximately 29,000 square feet of floor space in Bldg. 360 and generates an average of 400 tons of hazardous waste and 2.65 million gallons of contaminated rinse water annually. As federal and state environmental regulations continue to



OVERALL FLOW
FIGURE 8.1.1.1-1



MAEPNC CLEANING PROCESS
FIGURE 8.1.1.1-2 (SHEET 1 OF 2)



MAEPNC CLEANING PROCESS
FIGURE 8.1.1.1-2 (SHEET 2 OF 2)

stiffen, the costs of waste treatment/disposal will increase while the cleaning effectiveness of the line (where current chemicals will be replaced with less effective though less hazardous compounds) will decrease. MDMSC recommends that the bulk of the chemical cleaning processes be replaced with mechanical and cryogenic cleaning. This is described further in Paragraph 8.3.1 of this report.

The customers of MAEPNC report quality problems with the cleanliness of the parts. As no quality/rework data is tracked by MAEPNC or its customers, MDMSC cannot quantify (or even confirm) the existence of these problems. The 1990 PRAM plan includes a funding request for a cleaning line ahead of the eddy current inspection process (which MDMSC understands was not approved). The Gas Turbine Engine repair line is in the process of establishing their own cleaning line in Bldg 329, citing poor quality and long flow times from MAEPNC. While MDMSC's sampling of the flow of GTE parts through MAEPNC showed an average flow time of only 4 - 6 days, the parts returned to the GTE line do require considerable additional cleaning by GTE personnel before they can be inspected. MDMSC recommends MAEPNC begin tracking rework statistics immediately.

There are currently no projected changes to the MAEPNC process as a result of PRAM, REPTECH, DMIF, MST or other capital investment programs familiar to MDMSC. Two proposed projects (currently unfunded), however, were evaluated by MDMSC:

> A smart ventilation system was proposed to capture tank fumes at the tank surface, using a push-pull airflow system. This ventilation system would allow the elimination of the current overhead system, reducing fume concentration in the area and substantially reducing the noise levels. MDMSC's experience with conventional push - pull systems indicates that they are ineffective with tank surfaces of the size found in MAEPNC, especially where air agitation is used. The proposed vendor for the equipment, however, claims a proprietary design which alleviates these concerns. MDMSC was not provided design details and cannot evaluate these claims. MDMSC was briefed that the proposed contract (sole source) was cancelled based on SA-ALC concerns regarding the size/financial resource base of the vendor. If MAE engineers are

convinced of the value of this project, MDMSC recommends a competitive Request For Proposal (RFP) be issued, calling for a larger commercial company to provide/install the specified equipment, (using the actual manufacturer as a subcontractor). This will eliminate the concern over financial resources, while allowing the desired equipment to be procured.

A filtration system was proposed to filter and prolong the life of the alkaline rust remover used in MAEPNC. MDMSC has reviewed the proposal and concurs with the savings estimates shown. The use of this filtration technology is well-established in commercial industry and would reliably reduce the requirements for tank maintenance and waste disposal, while producing a small increase in cleaning quality. If SA-ALC elects to retain the current chemical tank processes, MDMSC recommends this proposal be reconsidered for funding.

The chemical cleaning process is hampered by poor cleaning effectiveness. The primary causes of this appear to be the difficulties experienced in obtaining high quality chemicals and the low efficiency of the air agitation systems used. MDMSC's recommendations regarding these problems are described in Paragraph 8.3.3.1 and 8.3.2 respectively.

Currently, there is no real scheduling of parts flow in MAEPNC. No data is available regarding flow times or WIP levels in MAEPNC and parts normally flow through on a Last In First Out (LIFO) basis. Occasionally, parts shortages in the assembly area trigger expediting actions where "hot" parts are hand carried through the cleaning process. This is discussed further in Paragraph 8.3.3.5 of this report.

8.1.1.1.1 Workload

MAEPNC is a high volume industrial cleaning center. It cleans an average of 100 - 150 thousand engine parts each month. Engines, modules, and MISTR items are disassembled ahead of the automatic cleaning line. Those parts requiring cleaning are sorted by cleaning process and placed in stainless steel wire baskets or onto plastic pallets. A stainless steel tag is attached to each part or basket then the parts/baskets are moved to MAEPNC.

The induction rate of parts into the line generally fluctuates as the engine workload cycles through the month. Engines are normally disassembled at the beginning of the month and assembled at the end of the month.

The current workload consists of aircraft engine parts from the Allison T56, General Electric TF39, Pratt and Whitney F100 series engines and from the Gas Turbine Engine (GTE) line. The GTE effort will be removed when the GTE cleaning line is established in Bldg 324.

The workload at the time the automatic line was installed in 1973, consisted of the T56, TF39 and the J79 engines. The utilization of the line was more than double what it is today. The J79 was replaced by the F100, which requires far more hand cleaning than automated cleaning, reducing the workload of the automatic line.

The parts are made from rubber, aluminium, steel, and titanium as well as various alloys. Each requires a special cleaning process depending upon its material content, the soil to be removed, and the inspection process that will follow. Because these parts are batched by cleaning process, MDMSC modeled the workload on the automatic line as large cleaning baskets of incoming parts (as described in the Task Order No. 14 proposal). Workload for the non automatic processes was modeled on small cleaning baskets.

Table 8.1.1.1.1-1 shows the average quarterly workload for MAEPNC, as reflected in the UDOS 2.0 model of MAEPNC.

MAEPNC WORKLOAD BY PROCESS
TABLE 8.1.1.1.1-1

PROCESS	QUANTITY	
automatic line	1,1836	large cleaning baskets
hand clean line	11,250	parts/baskets (small)
steam clean	15,270	parts/baskets (small)
blasting	31,340	parts/baskets (small)
vibrators	363,300	parts (865 loads)

20911

There is considerable overlap between processes. 93% of the parts which go through the automatic line also require additional hand, steam, and/or mechanical cleaning.

The GTE parts are delivered to MAEPNC in large cleaning baskets and go straight to the automatic line. These baskets are returned to the GTE line without being unloaded and never undergo any secondary (mechanical or steam) cleaning processes. The GTE workers complain about the quality of the cleaning provided by MAEPNC and are in the process of establishing their own cleaning line in Bldg 324.

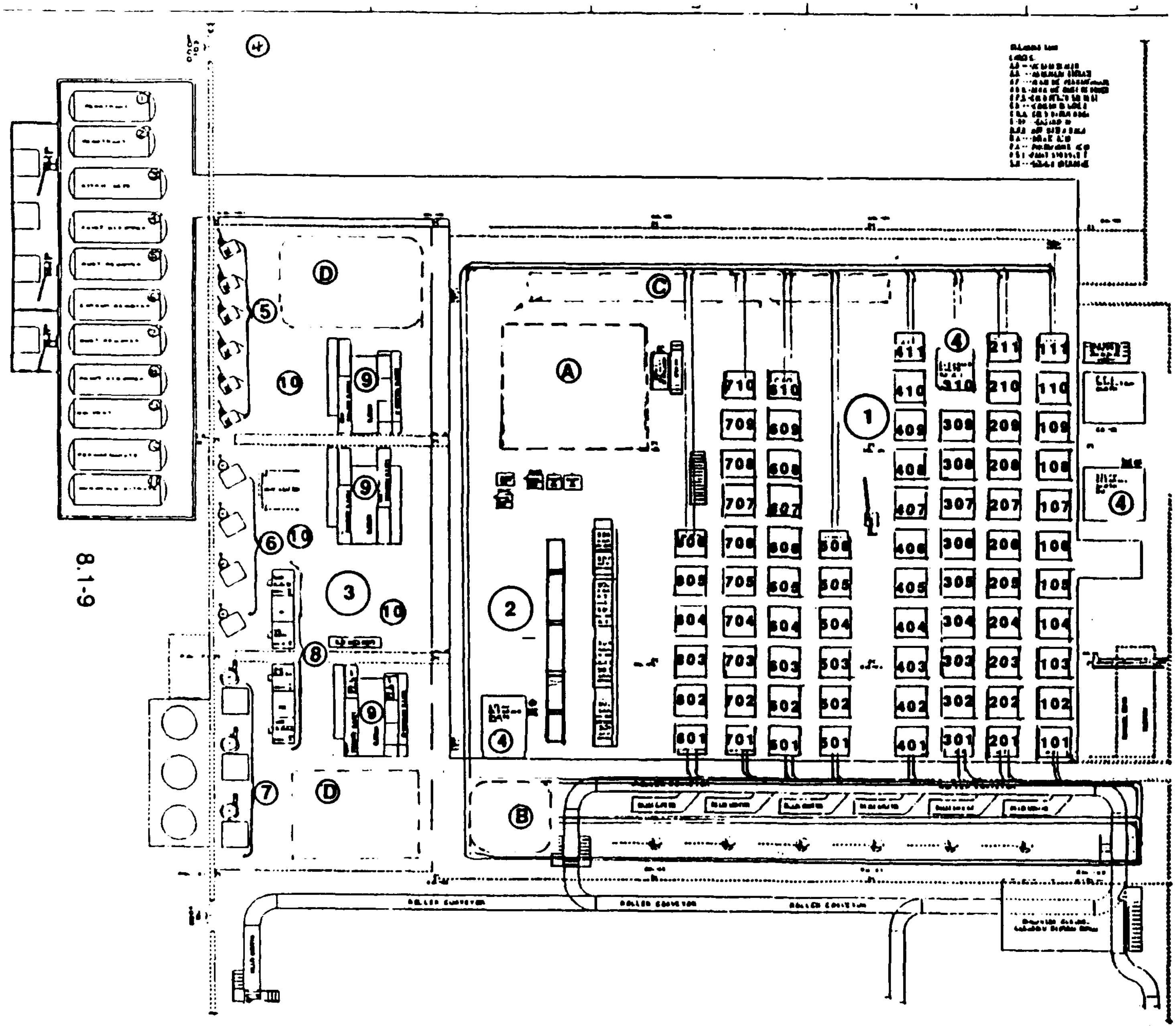
Workload figures for the automatic line, as well as other processes, were obtained from work logs maintained by production personnel at each process area and from MAE scheduling records.

8.1.1.1.2 Repair Technologies

The automated line consists of eight lines of 6 to 11 tanks each. There are 41 processes listed in the B/360 Chemical Cleaning Processes document found in each "picture book". (Samples from these books are included in Paragraph 5.0 of the DDB). These, plus additional variations for special circumstances, are programmed into the computer that controls the lines. Each line is designed for a particular type of cleaning. The tanks used, and the dwell time in the tank, are called out in the picture books as processes. Thus, L1P1 would be process one on line one and L1P6 would be process six on the same line. The layout of the tanks and the chemicals used in each are shown in Figure 8.1.1.1.2-1 and Table 8.1.1.1.2-1.

Parts/baskets are moved into MAEPNC by roller conveyor, in large module containers by the overhead transport system or by operators moving the parts. MAEPNC operators, using the information printed on the attached tag, either load parts/baskets into a cleaning basket or move them to the appropriate cleaning area. The flow of these large cleaning baskets is shown on Figure 8.1.1.1.2-2.

The quantity loaded into the cleaning basket depends upon; size, weight, quantity waiting to be cleaned, priority of parts/baskets, and whether or not the parts require special handling, (kept separate from each other, wired to the cleaning basket). The operators loading the baskets are careful to load for optimal circulation of cleaning solution around the parts. This is important because if too many parts are loaded in



LEGEND

1 AUTOMATIC CLEANING LINE
2 HAND CLEANING LINE
3 MECHANICAL CLEANING
4 STEAM BOOTHS
5 SMALL BLASTING CABINETS
6 MEDIUM BLASTING CABINETS
7 LARGE BLASTING CABINETS
8 WET BLASTING CABINETS
9 VIBRATION CLEANING EQUIPMENT
10 MEDIA STORAGE

WIP HOLDING AREAS

A READY FOR INSPECTION (FPI)
B READY FOR HAND CLEANING
C READY FOR BLASTING
D READY FOR BLASTING/VIBRATING

CHEMICAL AND MECHANICAL CLEANING SHOPS - BUILDING 360
FIGURE 8.1.1.1.2-1

CHEMICAL CONTENTS
TABLE 8.1.1.1.2-1 (SHEET 1 OF 3)

TANK NUMBER	TANK SOLUTIONS	CHEMICAL MAKE-UP
101		
102	ALKALINE RUST REMOVER	MIL-C-14460
103	ALKALINE RUST REMOVER	MIL-C-14460
104	WATER RINSE	
105	ACID DESCALER	TURCO SCALE-GO
106	WATER RINSE	
107	ALKALINE PERMANGANATE	POTASSIUM PERMANGANATE SODIUM HYDROXIDE
108	ALKALINE PERMANGANATE	POTASSIUM PERMANGANATE SODIUM HYDROXIDE
109	WATER RINSE	
110	ALKALINE RUST REMOVER	MIL-C-14460
111	WATER RINSE	
201		
202	ALKALINE RUST REMOVER	MIL-C-14460
203	ALKALINE RUST REMOVER	MIL-C-14460
204	WATER RINSE	
205	ACID DESCALER	TURCO SCALE-GO
206	WATER RINSE	
207	ALKALINE PERMANGANATE	POTASSIUM PERMANGANATE SODIUM HYDROXIDE
208	ALKALINE PERMANGANATE	POTASSIUM PERMANGANATE SODIUM HYDROXIDE
209	WATER RINSE	
210	ALKALINE RUST REMOVER	MIL-C-14460
211	WATER RINSE	
301		
302	PAINT STRIPPER	TURCO 6252
303	PAINT STRIPPER	TURCO 6252
304	PAINT STRIPPER	TURCO 6252
305		
306	PAINT STRIPPER	TURCO 6252
307	WATER RINSE	

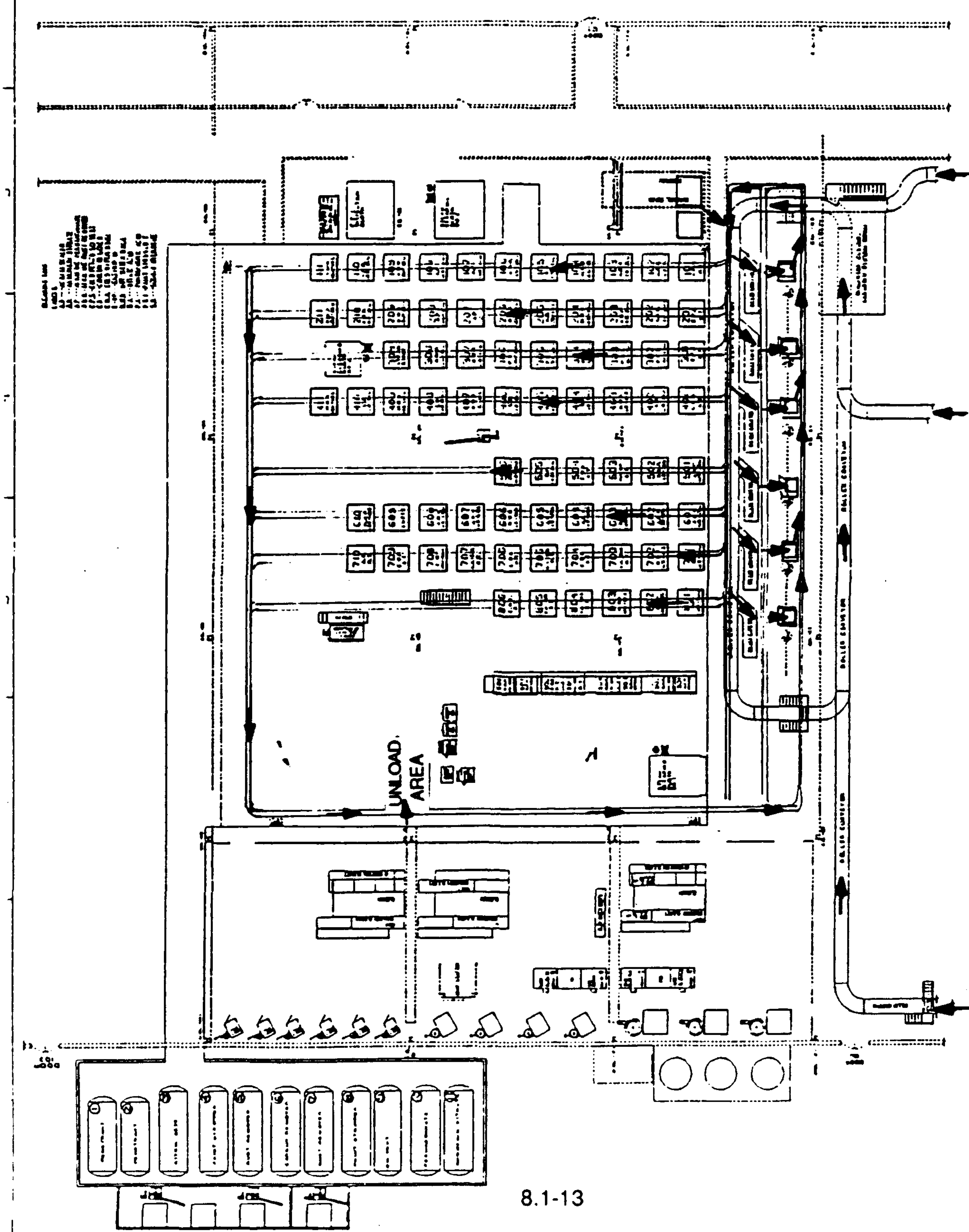
CHEMICAL CONTENTS
TABLE 8.1.1.1.2-1 (SHEET 2 OF 3)

TANK NUMBER	TANK SOLUTIONS	CHEMICAL MAKE-UP
309	STEAM RINSE	
401	PERCHLOROETHYLENE	PERCHLOROETHYLENE
402	CARBON REMOVER	PC-111D
403	WATER RINSE	
404	CARBON REMOVER	PC-111D
405	WATER RINSE	
406	CARBON REMOVER	PC-111D
407	WATER RINSE	
408	CARBON REMOVER	PC-111D
409	WATER RINSE	
410	CARBON REMOVER	PC-111D
411	WATER RINSE	
501		
502	WATER RINSE	
503	PHOSPHORIC ACID	PHOSPHORIC ACID
504	WATER RINSE	
505	SODIUM HYDROXIDE	SODIUM HYDROXIDE
506	WATER RINSE	
602	ALKALINE RUST REMOVER	MIL-C-14460
603	WATER RINSE	
604	ALKALINE RUST REMOVER	MIL-C-14460
605	ALKALINE RUST REMOVER	MIL-C-14460
606	WATER RINSE	
607	ALKALINE RUST REMOVER	MIL-C-14460
608	ALKALINE RUST REMOVER	MIL-C-14460
609	WATER RINSE	
610	WATER RINSE	
701	SODIUM HYDROXIDE	SODIUM HYDROXIDE
702	WATER RINSE	
703	NITRIC ACID	NITRIC ACID
704	WATER RINSE	
705	NITRIC ACID	NITRIC ACID

CHEMICAL CONTENTS
TABLE 8.1.1.1.2-1 (SHEET 3 OF 3)

TANK NUMBER	TANK SOLUTIONS	CHEMICAL MAKE-UP
707	NITRIC ACID	NITRIC ACID
708	ENSTRIP NP	ENSTRIP NP1 ENSTRIP NP2
709	WATER RINSE	
710	AMMONIUM NITRATE	AMMONIUM NITRATE
801	SODIUM HYDROXIDE	SODIUM HYDROXIDE
802	ALKALINE RUST REMOVER	MIL-C-14460
803	WATER RINSE	
804	NITRIC ACID	NITRIC ACID
805	NITRIC ACID	NITRIC ACID
806	WATER RINSE	
901	ALKALINE RUST REMOVER	MIL-C-14460
902	WATER RINSE	
903	ALKALINE RUST REMOVER	MIL-C-14460
904	WATER RINSE	
905	PHOSPHORIC ACID	PHOSPHORIC ACID
906	WATER RINSE	
907	ALKALINE RUST REMOVER	MIL-C-14460
908	WATER RINSE	

20912



AUTOMATIC CLEANING LINE

FIGURE 8.1.1.1.2-2

the cleaning basket, or if parts are arranged incorrectly they will not be cleaned as thoroughly as would otherwise be possible. MDMSC's recommendation to eliminate the safety wire step is described in Paragraph 8.3.2.2.

Transporters are attached to the loaded baskets and a process tag attached to the cleaning basket. As the basket passes the computer booth, the process is read from the tag and input to the computer.

The computer then directs the movement of the basket into and out of the specified tanks and to the unload position. If there are additional auto line cleaning processes required the basket is moved around to its starting point and then through the next cleaning process. When all automatic line processes are complete, the basket is lowered, unloaded manually, and the parts are moved to the next cleaning station or to inspection by the cleaning line workers.

If the computer goes down, all baskets are automatically removed from the tank. When the computer returns to service it remembers where it was and continues the process. The computer controlled processes may be converted to manual control at any time. For some cleaning processes with very long "as required" dwell times, the computer will put the basket into the tank and release it. The operator is then responsible for removing it when the cleaning has been accomplished. Line seven is currently a manually controlled line. It is used for cleaning parts that require long soak times (4 to 24 hours).

Parts that require a more tightly controlled process are cleaned on the hand clean line (line 9). The computer used on the automatic line cannot control the dwell time in the tanks to the tolerance required by many of the parts from the F100 series engines. Excess dwell time will etch these titanium alloy parts. The hand cleaning tanks currently contain the same chemicals as the automatic line. (A more effective cleaning solution has been ordered and delivery is expected in the near future.) Parts are loaded into small baskets (about 2 feet x 2 feet), dropped into the tank, soaked for the required time, pulled up and rinsed. Some also require hand scrubbing or scraping. Parts are manually moved to the hand clean line either from the end of the conveyor, from the front aisle, or from the automatic line unload area. The hand clean line is very labor intensive, and exposes the hand cleaning workers to much more frequent contact with the cleaning chemicals than the other processes.

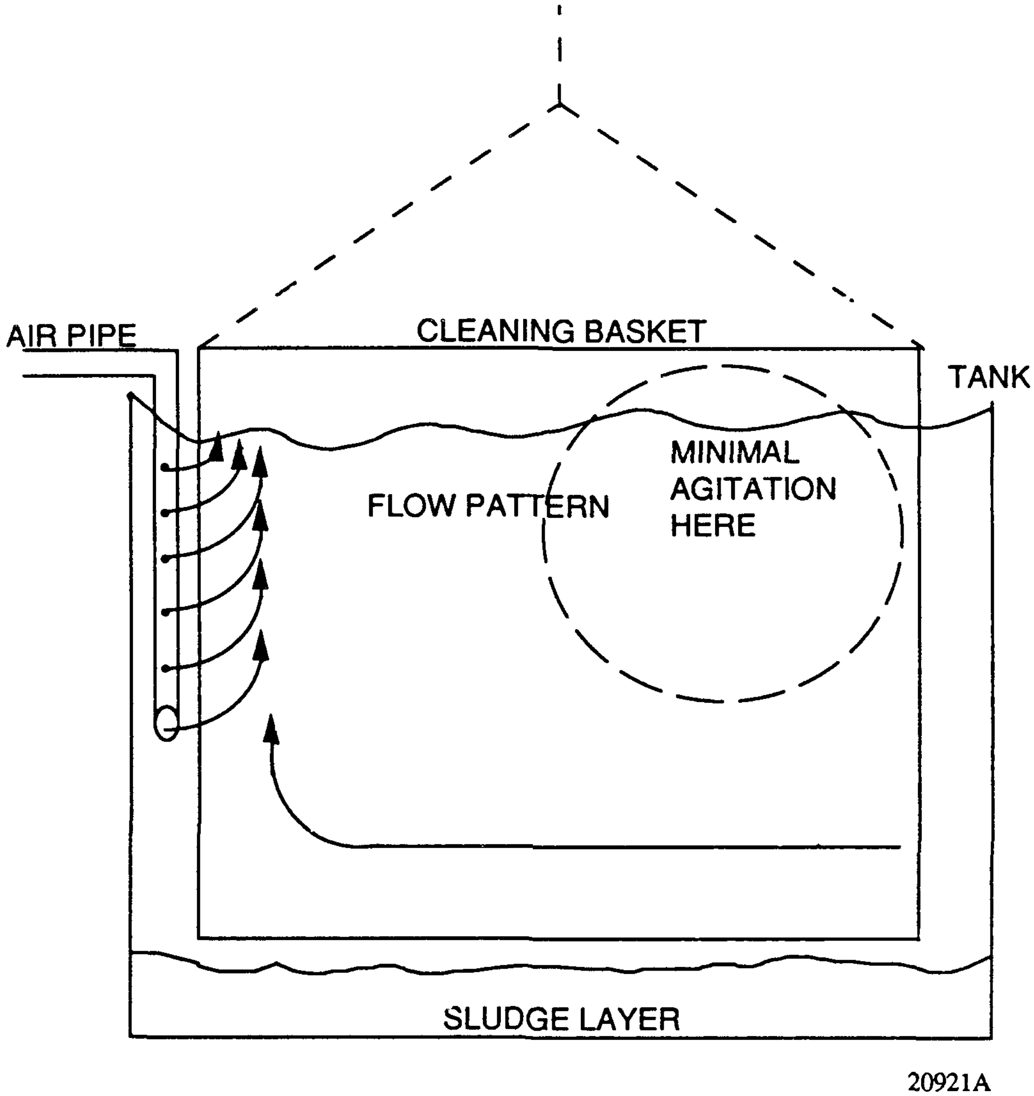
The automatic and hand clean lines have some difficulty in getting the parts clean enough to satisfy their inspection process customers. Environmental constraints prevent the use of many of the most effective chemicals. Of those chemicals which can be used, many of the most effective are difficult to obtain under current procurement regulations. This situation is described in more detail in Paragraph 8.3.3.1 of this report.

Agitation and additives increase the effectiveness of most cleaning solutions. Air agitation, as currently used in MAEPNC, has limited effectiveness. The air flow is limited to one side of the tank (with parts in the tank), and little fluid flow is generated. Holes in the air pipe become clogged by crystallization, further reducing the effectiveness. When completely blocked the air pipe must be cleaned or be replaced. Figure 8.1.1.1.2-3 shows the air agitation flow in these tanks. An alternate design for a mechanical agitation system is described in Paragraph 8.3.2.1. of this report and in the quick fix plan. MDMSC estimates that the use of mechanical agitation will produce a 30% increase in cleaning solution effectiveness.

Additives are used very little. An MAEPNC production chemist informed MDMSC that the venders had not suggested using additives with their product, so they did not use many.

The work effort in the mechanical clean area involves blasting and vibration cleaning using abrasive media. The soil is removed along with a micro-layer of the substrate material. The surface of the part is usually left slightly abraded and may require polishing prior to eddy current inspection.

There are eight blasting processes. The medias used are, walnut shells, ground corn cob, aluminum oxide (wet and dry), glass bead (wet and dry), and plastic media. The choice of blasting cabinet used depends upon the size of the part and the media required to clean it.



AIR AGITATION FLOW PATTERN
FIGURE 8.1.1.1.2-3

The operator moves to the part, picks it up and carries it to the cabinet. Parts awaiting blasting are stored on the floor wherever space is available. The operator may move the entire basket or stack of parts to a position beside the blaster. Depending upon the size of the part and the operator. The floor space is limited near the blasting cabinets. All material handling is performed by cleaning operators.

There is only one vibratory process. Parts requiring vibratory cleaning are placed in the machines in batches. Upon completion of a vibratory cleaning cycle, parts and media are discharged onto a separator, where the media is discharged onto a conveyer belt, and the parts are unloaded into a container. The media goes back into the machine for further use.

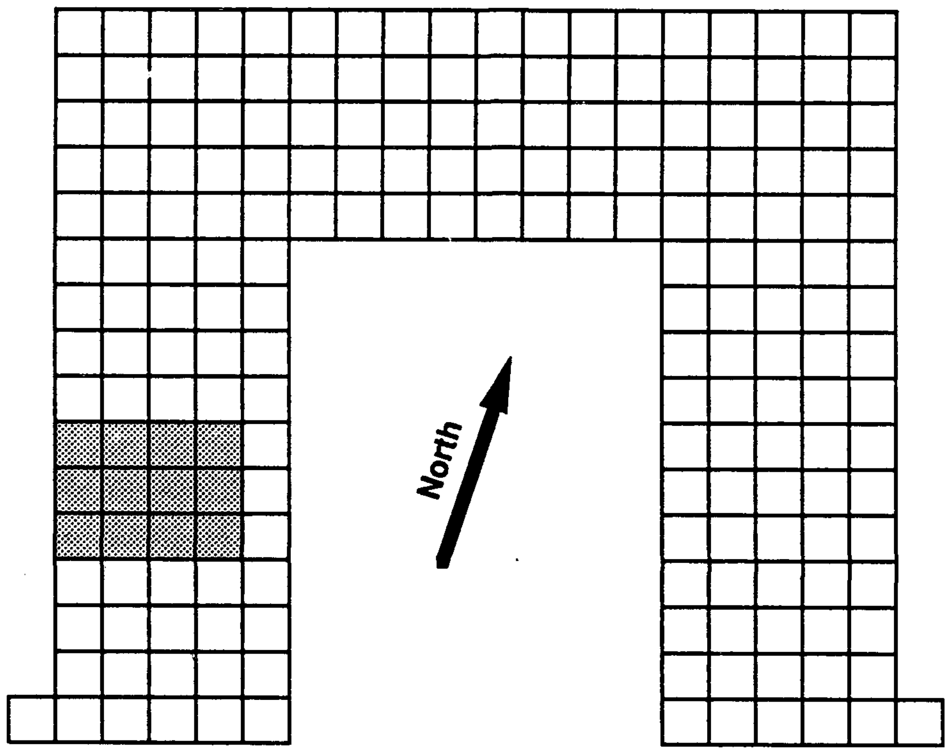
The parts completing blast and vibration cleaning often require a steam cleaning process as well. The steam cleaning removes any mechanical cleaning media adhering to the part's surface or trapped in the geometry of the part.

8.1.1.1.3 Facilities and Layout

MAEPNC occupies 29,000 sq feet in bldg 360, as shown on the layout drawing of Figure 8.1.1.1.3-1. The shaded area shown is MAEPNC. Parts flow into MAEPNC from the disassembly areas scattered through out the building.

MAEPNC is adequately well lit for the type of work performed, and MDMSC does not feel that increased light levels would improve productivity. The noise level is high and ear protection is required throughout the area. The largest source of the hazardous noise is the overhead compressors for the ventilation system. The building is air conditioned and the temperature in MAEPNC, though warm, is not oppressive. The fumes from the tanks are noticeable, however, MDMSC found no evidence that the level of fumes in the air was hazardous to the work force.

The ventilation system consists of large overhead fans and ventilation hoods mounted on the tanks. The working portion of the system is in the basement under the cleaning line. The hoods were designed to draw in the fumes rising from tanks but are not successful. A smart ventilation system designed to capture tank fumes from the tank surfaces, was planned for installation this year but the contract was cancelled.



Note: Shaded areas indicate areas studied.

20895

BUILDING 360 LAYOUT
FIGURE 8.1.1.1.3-1

MAEPNCs tanks do not have a filtration system. Sludge builds up in the bottom of the tank or in suspension in the solution decreasing the chemical's cleaning power. A filtration system was designed but has not been funded. The installation of such a filtration system would reduce the amount of sludge in the tanks and could be used to provide fluid movement in the tank thereby increasing cleaning effectiveness by 15 to 30%, reducing maintenance time on the tank, and increasing the life of the tank solutions (decreasing the toxic waste stream generated in MAEPNC).

Parts flow from the disassembly areas throughout the building into MAEPNC via conveyor belt, the overhead transport system (to drop stations), and hand trucks or carts. These parts are cleaned, then moved to an inspection process or occasionally back to the assembly area.

Those parts not requiring auto line cleaning are moved directly to the hand clean or mechanical cleaning areas. All part movement, other than the auto line, requires manual carrying by cleaning line workers.

Parts move through the auto line quickly, but stack up slightly at hand clean. The largest build up of parts, however, is ahead of the mechanical cleaning processes. There are multiple reasons for this build up of work in process (WIP) including: lack of proper scheduling - an insufficient number of blast operators, and poor material handling. Time is lost because operators must sometimes move 30 feet or more to obtain, and again to replace, parts. Valuable floor space is being used for storage, because some parts which are not needed by assembly are allowed to sit, sometimes for months. Lack of space and adequate material handling facilities make it difficult to establish an efficient flow. MDMSC recommends a new area layout, improved transportation and improved cleaning processes. This recommendation is discussed further in the focus study described in Paragraph 8.3.1.1 of this report.

8.1.1.1.4 Equipment

The equipment in MAEPNC consists of 88 chemical cleaning tanks, four steam booths, and miscellaneous support equipment. The tanks are identified by the line they are on and their placement in the line. Figure 8.1.1.1.2-1 shows the placement of these tanks, while Table 8.1.1.1.2-1 describes their chemical contents.

The tanks and their auxiliary support equipment are frequently in need of maintenance, despite the annual, semi annual, and quarterly Preventive Maintenance (PM) tasks that are performed by MADPH personnel. Section 3.0 of the DDB includes a description of the PM program in MAEPNC. Stainless steel tank liners have been installed in some of the tanks to decrease leakage/repair problems.

Steam lines, used to heat the tanks, are subject to breakage and leaking. Currently, any repair work on the steam lines requires the steam system to be shut down. MDMSC recommends an alternative design in Paragraph 8.3.3.2 of this report.

Agitation in the tanks is provided by air flowing from holes in pipes mounted on the side of the tanks. The holes become blocked by crystals formed over the pipe gradually reducing the air flow and the cleaning power of the solution. Pipes must be removed and replaced every two to three months. The removed pipe is then cleaned or discarded, depending on its condition. Paragraph 8.3.2.1 describes MDMSC's recommendations for an air-driven mechanical system to replace the air agitation and enhance the cleaning power of the chemical tanks.

The chemicals in the tanks are maintained by the equipment operators, under the guidance of the MAEIC chemist assigned to support MAEPNC. Rinse tanks are recharged weekly. This activity is normally performed on weekends, by MAEPNC production personnel working overtime. The waste chemicals are disposed of by the SA-ALC waste treatment facility or by outside contractors.

There are four steam booths and except for some failure of the steam lines, they are seldom out of service. The location of these booths is shown on Figure 8.1.1.1.2-1 The fourth is located behind the FPI line. The steam booth located near the hand cleaning line is used to clean tubes.

The mechanical cleaning area contains blasting cabinets (three sizes), wet blasting cabinets, and six vibration cleaning machines. New blasting cabinets were installed in 1989, and Preventive Maintenance has yet to be scheduled for these machines. There are two sets of wet blasters. One of each set uses aluminium oxide media and the other uses glass bead. Four of the vibration machines are old and need frequent repair. Two are in much better condition.

The automatic line was installed in 1973 and consists of the computer, overhead transporters, and the mono-rail. The transporters are the computer-controlled hoists which move the cleaning baskets around the mono-rail. The original manufacturer cannot supply adequate repair parts, making repairs difficult. A single computer controls the auto line. If it fails the line stops automatically and baskets must be moved manually.

The powered floor roller conveyor system is 695 feet long. Two legs start between the T56 and F100 engine disassembly area, and transports parts from disassembly to the MAEPNC loading point. Another leg is used to move parts from a drop station for the overhead transport system. The equipment cleaner loading the basket, controls the conveyor, turning it on to bring the parts to the desired position. The on/off switch is at the front of the line. If the operator is moving parts towards the end of the line, he must rush back to the switch to stop or start the conveyor. MDMSC's recommended change is described in Paragraph 8.3.3.3 of this report.

8.1.1.1.5 Work Force

There are 30 equipment cleaners, fourteen mechanical cleaners and two supervisors assigned to MAEPNC. Tube repair personnel and their supervisor are part of MAEPNC but were not included in this study. The supervisors report to a RCC Chief. The equipment cleaners are divided into computer operators, automatic line loaders/unloaders, hand cleaners, steam cleaners and the vibration machine operators. The mechanical cleaners operate the blasting equipment. Operators are assigned to specific work areas/duties but can be moved to other areas if the need develops. Table 8.1.1.1.5-1 shows the distribution of experience in MAEPNC, by wage grade.

The computer operator is responsible for operating the computer which directs the movement of the basket through the automatic line. One is assigned to first shift and one to second. The line can not operate unless the operator is in the booth. A qualified WG07 7009 worker can work as the computer operator for a maximum of thirty days.

WORKFORCE
TABLE 8.1.1.1.5-1

GRADE	CODE	AVERAGE YEARS OF EXPERIENCE	
WG08	7009	10	COMPUTER OPERATOR
WG07	7009	7	EQUIPMENT CLEANER
WG05	7009	2	EQUIPMENT CLEANER
WGO7	5423	7	MECHANICAL CLEANER
WGO5	5423	2	MECHANICAL CLEANER

20913

The loaders sort parts by process and load cleaning baskets. They do not actually clean parts and are primarily material handlers.

Hand cleaning operators load parts into baskets, dip in tanks, rinse and, if necessary, scrub or scrape parts to remove soils.

Equipment cleaners that are assigned to the vibrating machines dump up to 15 baskets of parts into the vibrator at one time. While a load is being vibration cleaned these workers complete the cleaning of the parts last unloaded. Several different types of blades must be sorted then loaded back into their original baskets. The vibration media has a tendency to become lodged in the parts and must be removed by hand.

Blasting is done by the 5423 WG05/WG07 workers. The supervisor of the mechanical cleaners spoke of the difficulty of motivating the the workers as there is little chance of transfer to another, more challenging position. This factor, coupled with the poor working conditions, impacts RCC morale.

Very little training is required for any of the tasks required of the MAEPNC cleaning personal, but experience may lead to improved performance.

The sick leave rate in MAEPNC is 3.7%, which is higher than the MAE average of 3.5%. In commercial industry, sick leave rates are often considered general indicators of morale.

The management of MAEPNC is to be congratulated for using disadvantaged personnel in positions where their disability causes little reduction of performance. Hearing impaired workers are used in the high noise areas.

8.1.1.1.6 Support Functions

The MAEPNC production process is supported by several functions within SA-ALC. The primary support functions are: scheduling, planning, engineering, chemical laboratory, and on-site maintenance.

8.1.1.1.6.1 MAES Scheduling

The scheduling function supporting MAEPNC operates differently from scheduling functions MDMSC has found in commercial companies. The amount of service provided to MAEPNC is much less than in the commercial world. Parts are moved to MAEPNC by personnel from other RCCs and moved to other RCCs by MAEPNC personnel. Priorities are set by, and parts expedited by, MAE production. Scheduling is involved very little.

Inductions into MAEPNC are driven by engine disassembly schedules. The bulk of the parts are then allowed to flow through MAEPNC without any attempt to schedule or capture flow times or performance data. Occasional shortages experienced in the engine assembly process trigger crisis expediting of "hot" parts through the cleaning process. Although this causes confusion and extra work in MAEPNC, it can actually reduce the amount of WIP inventory in MAE as a whole. The real problem with scheduling anything in MAEPNC is that the RCC is only a small part of the entire engine overhaul process. Until engines themselves are adequately scheduled, it is unlikely that any real scheduling can be done in MAEPNC. This is further discussed in Paragraph 8.3.3.5 of this report.

8.1.1.1.6.2 MAEE/Planning and Engineering

The planning function supporting MAEPNC is structured to provide some services similar to those provided by commercial planning organizations but does not address the cleaning process itself.

Planning provides the disassembly areas with a "picture book" showing the routing of each part through the appropriate process. Planning is responsible for keeping the "picture book" updated. Unfortunately the books become out of date; changes are made to the cleaning processes without changing the book, or disassembly workers find a different process they believe is more effective and change tag information without informing Planning.

MDMSC found no evidence of scheduled reviews of the picture books by MAEE. The reviews/updates appear to occur whenever process problems occur which trigger someone to request an examination of the planning documentation.

Planning does not provide documentation on the selection of specific chemicals/processes in the cleaning area. The decisions regarding what chemical to put in which tank, at what temperature and how long to immerse the parts is made jointly between production, the MAEIC chemist, and the MM process engineer. MAEE (Planning and engineering) appear to lack the chemical engineering personnel needed to adequately support/design chemical cleaning processes. This lack of support is undoubtedly a significant factor in the low-quality chemical problem described in Paragraph 8.3.3.1 of this report. MDMSC strongly recommends that the next MAEE engineering position which becomes vacant, be filled with a chemical engineer or a chemist with industrial experience.

Engineering support for MAEPNC is primarily involved with equipment and facilities. No chemical/process support is provided. Engineers from the engine lines may make changes in cleaning requirements, or inspection processes that effect MAEPNC, but do not provide guidance on changing the cleaning process itself.

8.1.1.1.6.3 MAEIC/Chemical Laboratory Support

The support provided by the chemical laboratory is very similar to the functions MDMSC has found in commercial companies. The Lab is responsible for monitoring the chemicals in the tanks and determining when maintenance is needed to keep them within process specifications. They also may solve special cleaning problems if asked by Production. They appear to have the only formal chemical process expertise in MAE.

MDMSC found a gray area between the responsibilities of MAEIC and MAEE. There is a need to have more detailed process specification for certain cleaning processes to enable procurement to purchase the proper chemicals, but it is not clear exactly who should write these specifications. MDMSC recommends that chemical process specifications be written by MAEIC until MAEE can hire a chemical engineer. While MAEIC may not have formal specifications responsibilities, they do have the expertise required.

8.1.1.1.6.4 On-Site Maintenance

MAEPNC receives good support from the maintenance personnel assigned in Bldg. 360. The maintenance workers are knowledgeable and feel they are part of the team keeping the cleaning area in production. MDMSC does not recommend any changes to the current on-site maintenance practices.

8.1.1.1.7 Strengths and Weaknesses

This paragraph looks at the elements of the cleaning process and rates them as areas of strength or weakness in the MAEPNC processes.

Classic economic theory lists the elements necessary to add value to a product as: labor, raw materials, capital (investments) and information. Table 8.1.1.1.7-1 breaks down these categories into subcomponents that apply to the cleaning (added value) of engine parts and gives MDMSC's evaluation of the relative strength of MAEPNC in each area. The evaluation is subjective: based on MDMSC's study of several commercial aviation repair depots and on MDMSC's own practices.

MAEPNCs strongest areas are in the quality of its work force and the availability of adequate capital investment in the automated cleaning line. While worker skill levels are lower than those found in many other areas in MAE, they are adequate for the

MAEPNC STRENGTH/WEAKNESS EVALUATION
TABLE 8.1.1.1.7-1

Very Weak	Weak	Moderate	Strong	Very Strong
1	2	3	4	5

CATEGORY	SCORE	COMMENTS
LABOR		MAEPNC has the minimum number of personnel to support current workload. The skill level of the workers is low but the cleaning effort requires little skill. The lack of challenge and chance to upgrade causes some detriment to morale.
• Quantity	3	
• Skill Level	4	
• Morale/Motivation	2	
Ave	3	
RAW MATERIAL		MAEPNC is dependent upon the disassembly areas to supply parts to be cleaned.
• Parts	N/A	
Ave	N/A	
CAPITAL		The facilities can support current and projected workloads. The automatic line has more capacity than is now needed. The type of workload has changed, causing the automatic line effort to decrease and the hand cleaning line to increase. The blasting cabinets have more capacity than is currently required. The cabinets are only one year old, but are very labor intensive. The vibrating cleaning machines also have more capacity than is currently required.
• Facilities	2	
• Automatic Cleaning Line	3	
• Hand Clean Line	2	
• Blasting Machines	3	
• Vibrating Machines	3	
Ave	2.6	
INFORMATION		Traditional management information is practically nonexistent in MAEPNC. The schedule is dependent on the disassembly/assembly areas. No one has any idea of the cost or of the return on investment produced by capital expenditures. Process data is available, although not always completely up to date. No performance data is collected, making planning and scheduling difficult. Quality/Rework is not tracked.
Management		
• Schedules	1	
• Plans	2	
• Cost Performance		
Process	1	
• Tech data	2	
• Performance	2	
Ave	1.6	

20829A

work in MAEPNC. Supervisors report that this situation (lower than average skill requirements) makes transfers/promotions difficult. This situation, coupled with the unpleasant working conditions, has a detrimental effect on the RCCs morale.

The tanks and associated equipment on the automated line are old, but quite well maintained. They have relatively low failure rates and seldom cause a significant work stoppage. The actual capacity of this line is 200 - 300% higher than the current workload.

The hand cleaning line is much busier than the automated line. During the UDOS model experiments at elevated workload levels, what queues were observed, were in the hand cleaning line. Under extremely heavy workloads, this line will be the first bottleneck in MAEPNC.

MAEPNCs greatest weakness is in the area of management information. While Production management is closely involved with the entire process, they often lack key data elements needed to make decisions. Prime among these are:

- Schedules showing when parts are needed/priority of parts.
- Quality performance data showing process quality/rework statistics.
- Cost of operations in various steps in the MAEPNC processes.

Without this type of data, it is impossible for managers to accurately assess the functioning of their process(es) or evaluate the potential benefits of recommended improvements.

8.2 SIMULATION MODEL

8.2.1 MAEPNC - Automated Cleaning Line

In accordance with the Task Order No. 14 SOW, a set of computer flat files was constructed using data on the MAEPNC automated cleaning line process. These flat files, when run using the UDOS 2.0 simulation model, produced a valid simulation of the baseline MAEPNC production process.

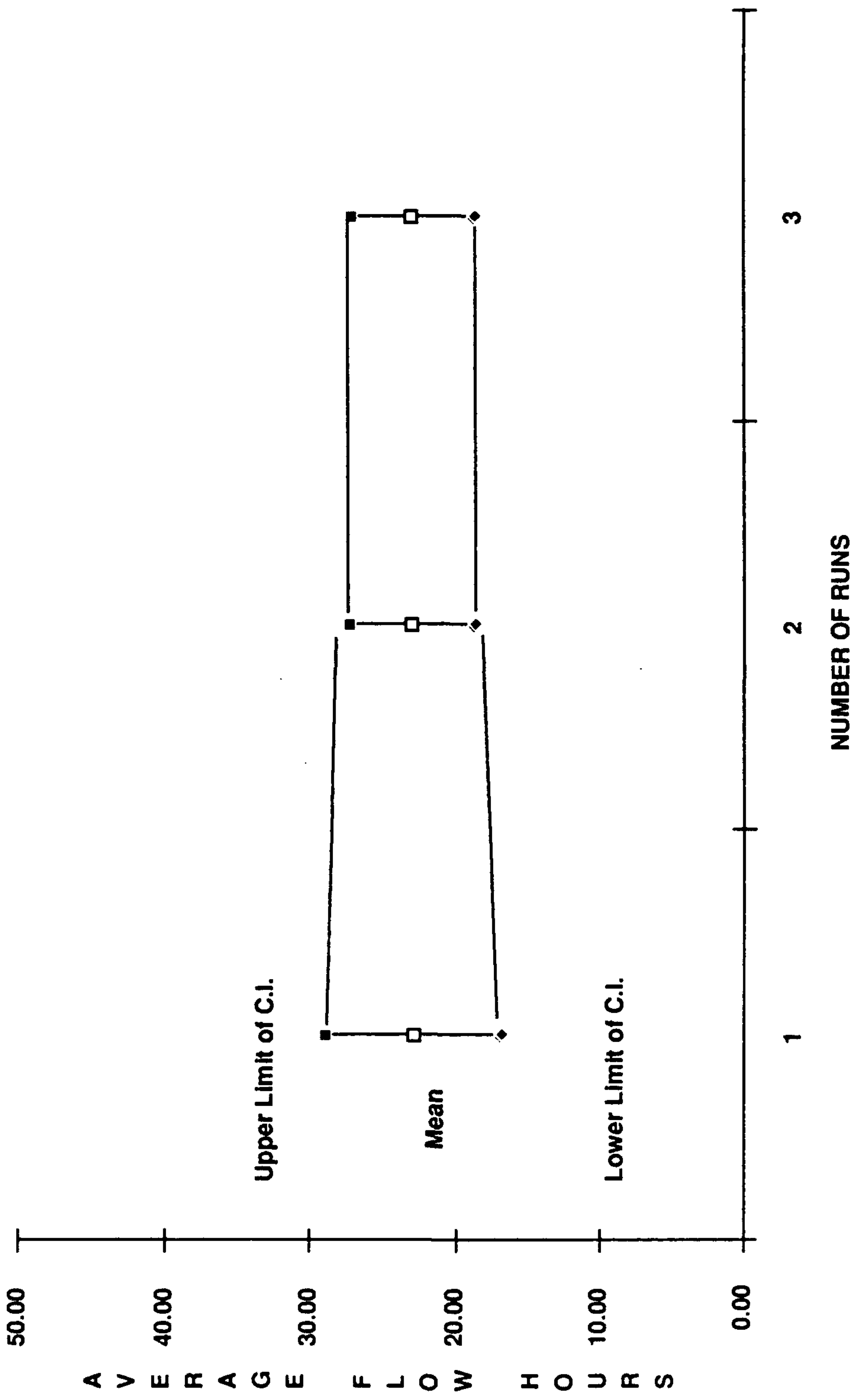
The data used to construct the MAEPNC model was obtained from several sources, as shown in Section 8.0 of the DDB. The most significant sources were production logbooks and the process "picture books" used to assign specific parts to the appropriate cleaning process. This data was reviewed by production management and support personnel prior to its use in the simulation model.

Validation was performed in accordance with the Acceptance Test Procedure (ATP) called out in MDMSC's proposal. Details of the validation procedure can be found in Section 8.0 of the DDB and the validation report submitted by MDMSC as CDRL item 14A017. The final phase of validation was witnessed by the MAWFT IPI working group member at SA-ALC.

As no historical flow time data was available for validation purposes (WCDs are not attached to the parts until both the cleaning and inspection processes have been completed and no other records are kept), the model was validated against throughput and resource utilization figures. These figures were subjectively evaluated by production and scheduling personnel for validity.

The validated model was run at three random seeds. At a 95% confidence interval, the flow time variance attributable to random seed changes decreased insignificantly between two seed runs and three. This led MDMSC to the decision to use two random seed runs for each model experiment. Figure 8.2.1-1 shows this graphically. More detail can be found in Section 8.1 of the DDB.

The automatic cleaning process in MAEPNC is characterized by extremely low process variability and the complete lack of interaction between the various lines. This circumstance made the area extremely simple to model, but also tends to limit the



20915

MAEPNC - 3 RUN 95% CONFIDENCE INTERVAL
FIGURE 8.2.1-1

value of the model. In the future, MDMSC does not recommend such simple automated processes as candidates for UDOS simulation modeling. Figure 8.2.1-2 illustrates the flow of parts through the automated line, as modeled in the UDOS simulation.

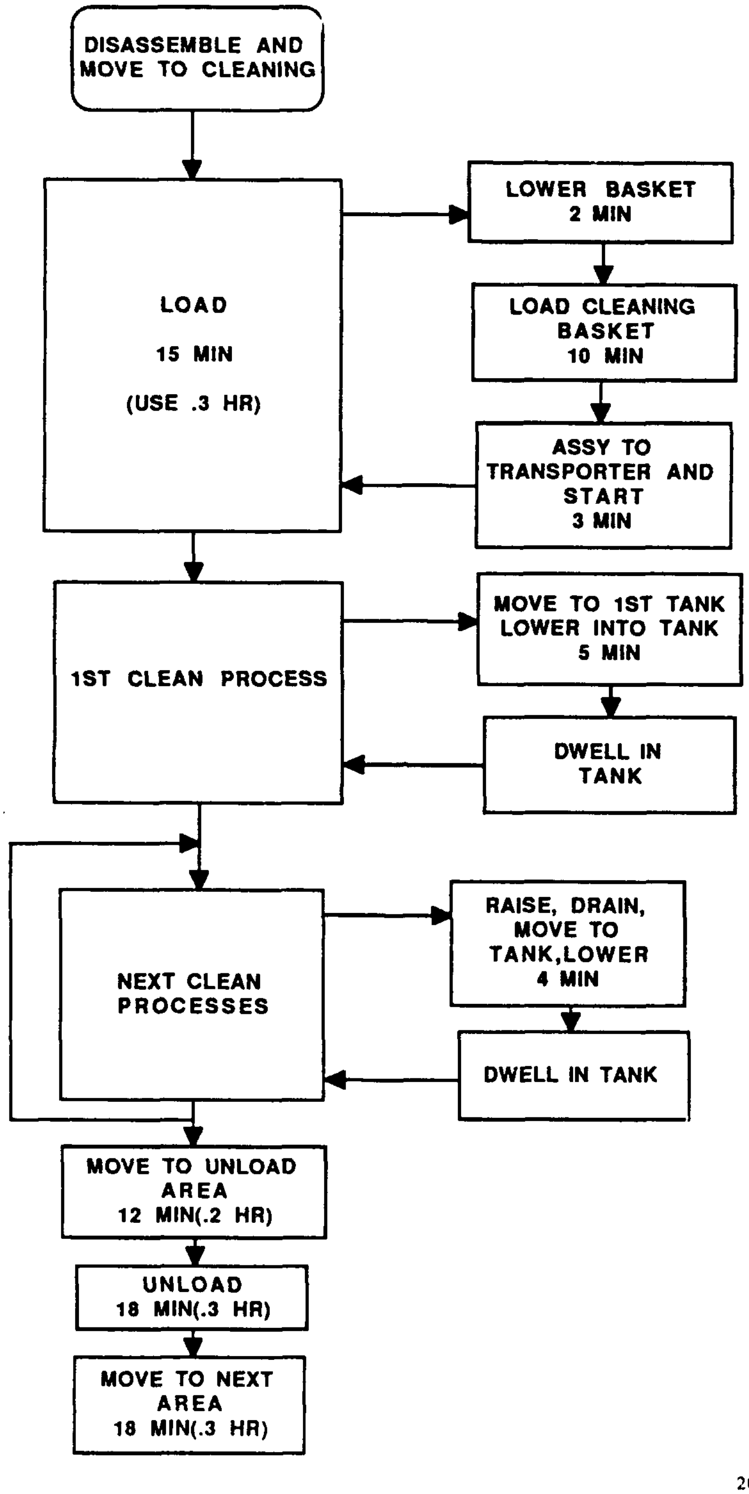
In an attempt to increase the SA-ALC return from this task order, MDMSC constructed a second UDOS 2.0 model of the secondary cleaning processes used in MAE (blasting, vibration, hand cleaning, and steam). Although not required by the Task Order 14 SOW, MDMSC engineers felt that this additional effort (at no extra cost to the U.S. Air Force) would allow more fruitful model experiments to be conducted. Unfortunately, the SA-ALC reorganization occurred during the modeling process and left MAEPNC production personnel too busy to support the validation process. The second model was finally validated on 23 October 1990, leaving MDMSC insufficient time to conduct experimentation with the second model. This model is available for MAE use, however, and experiments may be conducted by Air Force personnel if desired.

8.2.1.1 Brainstorming

Following model validation, a brainstorming session was conducted to determine the factors and levels to be used in experimentation. This session was chaired by MDMSC and included representatives from MAEPNC Production, Scheduling, Quality Assurance, Engineering, and MAWFT. The following list of factors/levels was developed during this session:

<u>**IDEAS FOR MAEPNC EXPERIMENTS**</u>

FACTOR	LEVELS	
1) Increase T56 Workload	As Is	Increased by 20%
2) Combine Lines 1 and 2	As Is	Combined
3) Move the Workload from Line 6 to Lines 1 and 2	As Is	Workload moved
4) Study Interactions between each factor.		



SIMULATED FLOW THROUGH THE AUTOMATIC LINE
FIGURE 8.2.1-2

After examining the list and the validated model of MAEPNC, MDMSC prepared a recommended experimental design. This recommendation was discussed with MAWFT and MAE engineering and accepted without change. This design was subsequently modified when T-56 workload data proved to be unobtainable. Details of the experimental designs are included in Paragraph 8.2.1.1.1 of this report.

8.2.1.1.1 Design

The experimental factors selected during brainstorming were fitted by MDMSC into an L_8 Taguchi orthogonal for experimentation. This array was selected because it would give complete visibility to all interactions between the factors chosen. The experimental factors did not completely fill the array (experiment 7 was unused) but, as no one could recommend an additional factor, this design was accepted.

When MDMSC attempted to construct the model files to support this experiment, it was discovered that the induction workload (drawn from MAEPNC production logs) was not segregated by engine type. As a result, it was impossible for MDMSC to accurately determine what workload increase would simulate a 20% increase in T-56 work. MAE engineering and MDMSC made a fruitless attempt to capture this data from the MAE disassembly process.

Rather than use an estimate of the data required, MDMSC recommended a change in the structure of the experiment. The T-56 workload sensitivity assessment would be made for the entire automated line. The workload factor would be removed from the array and modeled outside the array as a noise factor. The array would be repeated at multiple workload levels and a signal to noise ratio calculated. This approach was approved by MAE engineering.

MDMSC selected an L_4 Taguchi orthogonal array for the new experimental design. This array contained the two remaining factors and allowed visibility of any interactions that might exist. Table 8.2.1.1.1-1 shows the design of this final array.

The levels for the workload noise factors were established at 100 - 200% workload at 20% intervals. Levels of 250 and 300% were also planned, but extremely long model

MAEPNC L_4 EXPERIMENTAL DESIGN (FINAL)
TABLE 8.2.1.1.1-1

(LINE 1)

	CONTROL FACTORS			NOISE FACTORS					
EXP	LINES 1 & 2 COMBINED	LINE 6 MOVED TO LINE 1 & 2	INTERACTION 1 X 2	100%	120%	140%	160%	180%	200%
1	AS IS	AS IS	1						
2	AS IS	MOVED	2						
3	COMBINED	AS IS	2						
4	COMBINED	MOVED	1						

20916

run times at these levels (caused by queues building in Lines 7 and 8) made this impossible. These levels were analyzed using data from the UDOS preprocessor usage report.

8.2.1.1.2 Conduct of Experiments

All experimental runs were conducted by MDMSC in accordance with the SOW and Task Order 14 proposal. The experiments in the L_4 array were run using two different random number seeds (for a total of 48 model runs) and the results averaged.

8.2.1.2 Experimentation

Experimentation was conducted by MDMSC using the MAEPNC simulation mode, in accordance with the Task Order 14 proposal and SOW. Actual model runs were made on both MDMSC and SA-ALC computers. As the automated cleaning line already has substantial extra capacity, the experimental factors dealt with the combination of cleaning lines to increase utilization and allow the freeing of Building 360 floor space for other purposes.

8.2.1.3 Analysis

This paragraph describes the results of the UDOS model experiments conducted by MDMSC for MAEPNC under Task Order 14.

8.2.1.3.1 Taguchi Experimentation

The results of the Taguchi experiments are displayed graphically in Section 8.1 of the DDB.

An analysis of these results was performed using the methodology developed by Dr. Genichi Taguchi, as specified in the IPI general SOW. The detailed results of this analysis are contained in Section 8.1 of the DDB. A summary of the results for flow time is shown in Table 8.2.1.3.1-1, and for WIP inventory in Table 8.2.1.3.1-2. Although the purpose of this experiment was not to optimize any combination of these factors, but rather, to test their effect on the automated cleaning lines sensitivity to changes in workload, a confirmation run at the "optimum" configuration is presented for experimental validation purposes.

MAEPNC L_4 EXPERIMENTATION RESULTS - FLOW TIME
TABLE 8.2.1.3.1-1

LINE 1 - FLOW TIME

	WORKLOAD LEVELS (NOISE)							
EXP #	100%	120%	140%	160%	180%	200%	AVE	S/N RATIO (db)
1	16.0	16.7	17.7	19.1	20.2	21.4	18.5	41.0
2	16.2	17.8	19.1	21.4	23.5	25.2	20.5	41.9
3	17.7	18.7	20.7	23.0	24.9	26.3	21.9	42.5
4	19.4	24.8	29.2	34.6	38.8	44.7	31.9	45.9

NOTE: Results at each noise level are the average of two runs at different random seeds.

20917

MAEPNC L_4 EXPERIMENTATION RESULTS - WIP

TABLE 8.2.1.3.1-2

LINE 1 - WORK IN PROCESS

	WORKLOAD LEVELS (NOISE)							
EXP #	100%	120%	140%	160%	180%	200%	AVE	S/N RATIO (db)
1	2.1	2.6	3.1	4.0	4.8	5.6	3.7	27.4
2	3.7	5.1	6.1	7.8	9.9	11.7	7.4	33.5
3	4.6	5.9	7.5	9.6	11.7	13.7	8.8	35.0
4	5.7	13.8	19.0	25.8	32.4	41.3	23.0	43.8

NOTE: (1) Results at each noise level are the average of two runs at different random seeds.

(2) The large change in S/N Ratio between experiments is caused by the combining of workloads into Line 1. As these workloads are shifted into Line 1, the WIP at Line 1 increases while the WIP at the other lines decrease proportionately. This pronounced change is caused by the MDMSC decision to show only Line 1 results, not by a real increase in WIP sensitivity between experiments.

20918

Using a "Bigger is Better" analysis (assuming that by reducing the available resources, we will increase flow time and the optimum configuration we wish to study is the one with the fewest resources), the predicted optimal configuration is:

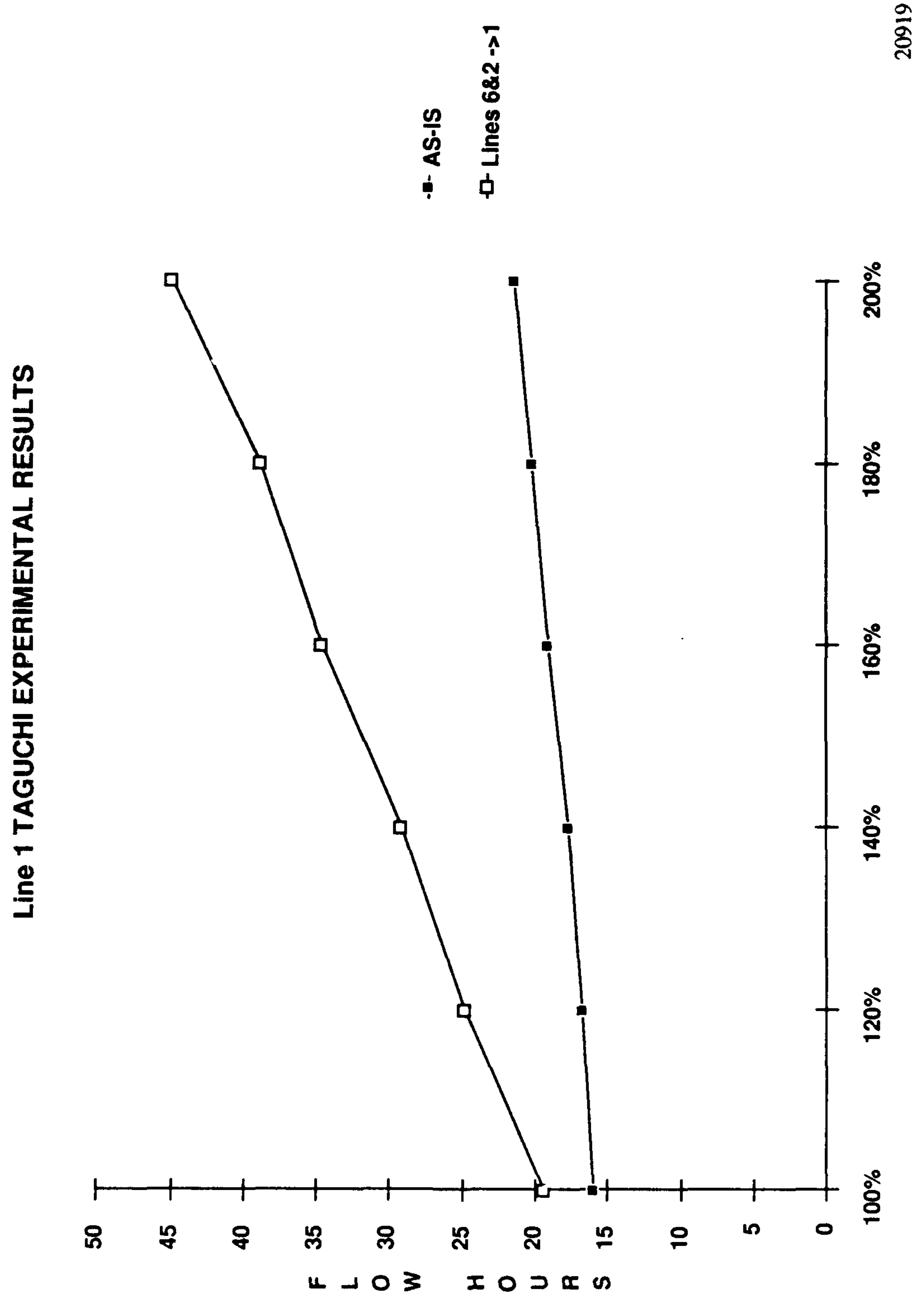
FACTOR	LEVEL
1) Combine Lines 1 and 2	Combined
2) Move Line 6 to 1 and 2	Moved
3) Interaction 1 x 2	N/A (no interaction observed)

The predicted average response for Line 1 flow time (chosen as the most important output measurement) is 31.9 hours. The average flow time for experiment 4 (which matches the predicted optimum configuration) across all noise levels is 31.9 hours. MDMSC concludes that the experiment has been adequately confirmed.

Figure 8.2.1.3.1-1 illustrates the effect of changes in flow time at various workload levels. The comparison between the As Is (Baseline) and the "optimum" experimental configuration shows that the new configuration is more sensitive to workload changes than the baseline. This is further indicated by the 4.9 db increase in signal to noise (S/N) ratio between Experiment 1 (Baseline) and Experiment 4 (optimum). The sensitivity is a function of the current overcapacity of the line. The response shown by the optimum is a common one - as workload increases, queues build and flow times lengthen. The extremely robust response of the baseline configuration is typical of substantial overcapacity. At 250% of current workload (studied using the UDOS 2.0 preprocessor usage report) tanks 7 and 8 (Alkaline Permanganate) were used only 32% of the available time, while all other tanks in Line 1 were used even less. At 300% of current workload, these tanks were still only used 53% of the available time. MDMSC concludes that the automated cleaning line in MAEPNC has substantial excess capacity.

The following paragraphs discuss the results of each factor and offer MDMSC's recommendations:

FACTOR 1 - MDMSC recommends MAEPNC close automatic Line 1 and transfer all Line 1 workload to Line 2. This factor produced only small increases in flow time (average of 2 hours/basket) and WIP (2 baskets/year) and would allow the elimination



WORKLOAD SENSITIVITY COMPARISON
FIGURE 8.2.1.3.1-1

of 11 cleaning tanks. This would free approximately 1200 square feet of production floor space in Building 360, and save the equipment maintenance manhours currently expended on the equipment in Line 1. Line 1 was chosen for elimination because of its position at the outer edge of the tank line. NOTE: Making this change would not reduce the use (and disposal) of chemicals in MAEPNC. Chemical replacement/disposal is driven by workload (amount of soil removed), not by calendar time. The replacement rate of the chemicals in Line 2 would increase in proportion to the increased workload. This recommendation is discussed further in Paragraph 8.3.2 of this report, and in the Task Order No. 14 quick fix plan. This factor shows no interaction with Factor 2.

FACTOR 2 - MDMSC recommends MAEPNC close automatic Line 6 and transfer all Line 6 workload to Line 2. This factor produced only small increases in flow time (average of 1 1/2 hours/basket) and WIP (1.25 baskets/year), and would allow the elimination (or shut-down) of 10 cleaning tanks. This would free approximately 1200 square feet of production floor space in Bldg 360 and save the equipment maintenance manhours currently expended on the equipment in Line 6. Because Line 6 is in the middle of the tank lines, the contents of Line 8 would have to be transferred to the first 6 tanks of Line 6. An alternative would be to add an 11th tank to the end of Line 6 and transfer the contents of the tanks in Line 2 (now combined with Line 1) to those in Line 6. This would free a total of 2400 square feet of floor space at the edge of the cleaning area. All chemical replacement considerations described in Factor 1 are applicable to Factor 2 also. This recommendation is described further in Paragraph 8.3.2 of this report and the Task Order No. 14 quick fix plan. This factor shows no interaction with Factor 1.

8.3 CONCLUSIONS

8.3.1 Focus Studies

8.3.1.1 Recommendation For A Focus Study: To Replace Current Chemical Clean Process With CO_2 Blasting

This paragraph describes an improved engine part cleaning process using frozen Carbon dioxide (CO_2) as a blasting media. The recommended procedure is designed to improve the cleaning quality and reduce the toxic waste stream produced in MAEPNC.

8.3.1.1.1 Rationale Leading to Change

An MDMSC study of the MAEPNC automatic cleaning line reveals several process problems:

- It was designed for a different, larger workload and currently has 200 - 300% excess capacity. The hand cleaning line, however, is the recipient of the bulk of the new workload (Titanium F100 engine parts) and is quite heavily utilized.
- The automatic cleaning processes do not clean to the quality standards required by the modernized inspection processes used in MAE. 93% of all parts cleaned in the automatic line must also undergo labor-intensive, hand, mechanical, and/or steam cleaning before being inspected.
- The automated cleaning line currently produces an average of almost 400 tons of hazardous chemical waste (solid and liquid) each year and approximately 2.66 million gallons of contaminated rinse water. Table 8.3.1.1.1-1 shows the breakdown of this waste stream since 1988. The cost of disposing of this waste is estimated at $763,000 for in-house treatment (performed by the SA-ALC waste Treatment Facility) and $44,000 in outside vendor costs, annually. The cost of rinse water disposal is estimated at $178,000 annually. Given the present public sensitivity to environmental concerns and the pressure on state and federal agencies to tighten waste treatment requirements, MDMSC predicts that these costs will rise significantly in the next 5 years. In addition, some of the chemicals currently in use (perchloroethylene in particular) will no longer be permissible for industrial use, under the Montreal convention (for chlorinated Flourocarbon discharge reduction) and similar legislation. The substitute compounds currently available are less effective and will further reduce the quality and effectiveness of the automated line.

MAEPNC TOXIC WASTE STREAM
TABLE 8.3.1.1.1-1

YEAR	WASTE STREAM			DISPOSAL/RECHARGE			
				IN-HOUSE		VENDOR	
	SOLID (LBs)	LIQUID (GAL)	TOTAL (LBs) (1)	VOLUME (LBs)	COST	VOLUME (LBs)	COST
1988	0	101,781	844,782	695,540	$809,847	149,242	$41,756
1989	3,763	87,126	726,909	543,750	$632,935	183,159	$50,894
1990 (2) (1st 9 months)	4,796	80,293	671,228	545,103 .	$634,545	126,126	$28,993
				AVE=	$762,947	AVE=	$43,769
					TOTAL AVE=	$806,716	

(1) Gallons converted to Lbs at 8.3 Lb/Gal
(2) Through September 1990.

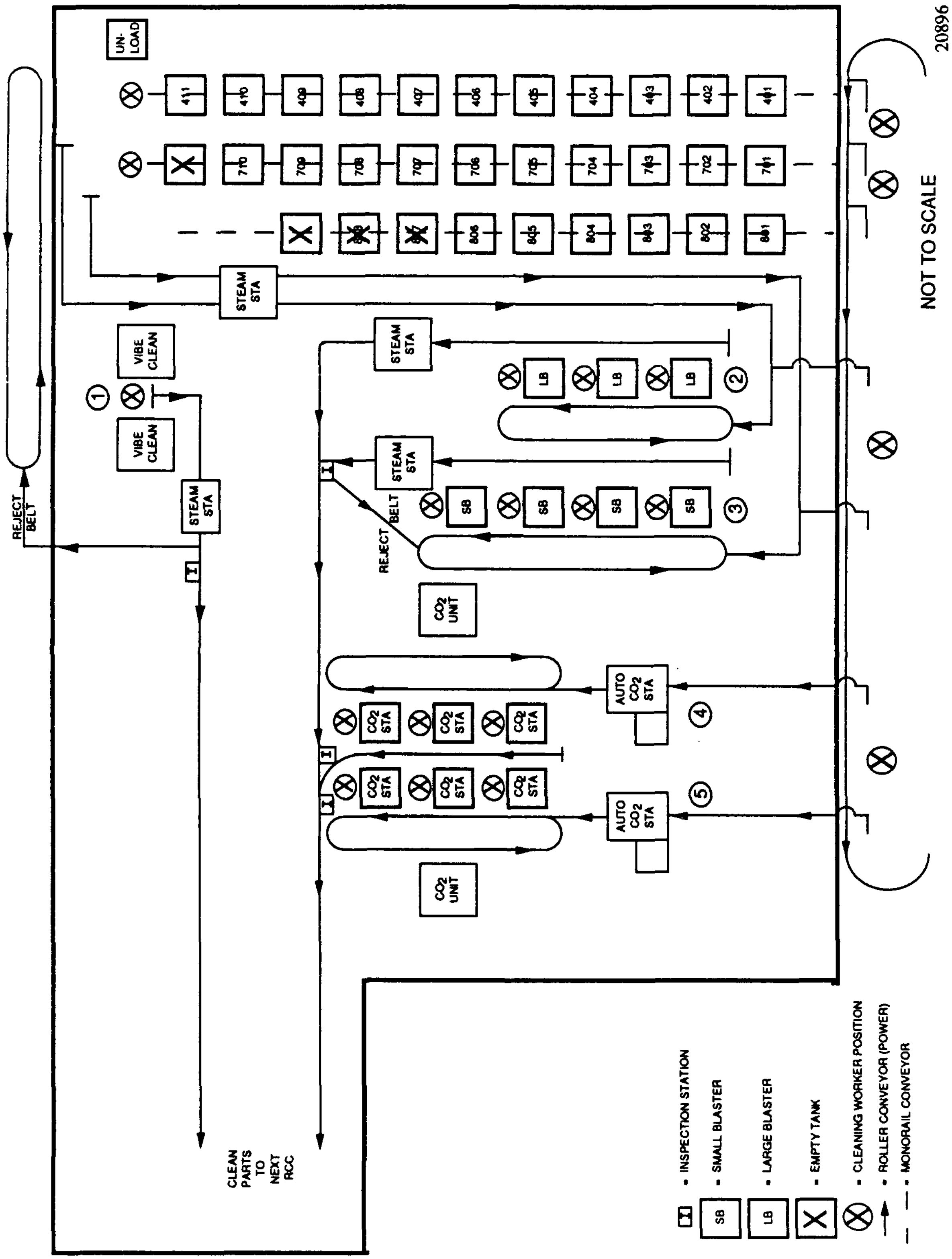
NOTE: DOES NOT INCLUDE RINSE WATER

20897

MDMSC proposed a major redesign of the cleaning process used in MAEPNC. The bulk of the chemical cleaning will be removed and replaced with blasting processes using frozen CO_2 (dry ice) as a medium. This change will increase the quality of the cleaning process (which already requires extensive blasting) and substantially reduce the hazardous waste stream currently produced. The CO_2 used in this process is non-toxic (food grade - FDA approved), evaporates on contact, requires no special handling or disposal and is environmentally friendly. Since it is originally captured as a waste product from other industrial processes, it does not increase the chances of a possible onset of a "greenhouse" effect in the Earth's atmosphere.

MDMSC has tested this process on sample parts provided by MAEPNC and concluded that it will remove greases, oils, carbon coking, paint, and light-to-medium rust and scale, with excellent effectiveness. It will also strip sealants, adhesives, gaskets, and decals. It will <u>not</u> adequately remove heavy corrosion, primer from very thin substrates, or burnt carbon which has bonded to the substrate surface at the molecular level. Video tape documentation of the tests has been provided to MAE engineering. Photographs of the tested parts have been included in Section 9.1 of the DDB, along with more detailed notes on the tests and the process. The tests were performed at the vendor's facility (Cold Jet Inc.) in Cincinnati, Ohio. Although SA-ALC personnel were invited to attend, TDY budget constraints prevented it.

MDMSC proposes that the chemical cleaning processes used in automated Lines 4 (carbon removal - PC111D), 7 (Nitric Acid Nickel stripping) and 8 (Nitric acid flame spray removal) be retained along with the dry blasting process and steam cleaning. Extra tanks at the end of Line 1 - 3 could be used for specialty chemical processes. All other chemical processes and wet blasting would be replaced with CO_2 blasting. To achieve the required production throughput (100 - 150,000 parts per month) MDMSC recommends a powered conveyor system and automated blasting/steaming stations. A picture of the proposed layout is included as Figure 8.3.1.1.1-1. The tank lines currently numbered 1 - 3 would be refilled with the solutions used in Lines 4, 7, and 8. All other tanks would be removed. The goal of this layout would be to establish a smooth flow of parts, with minimum batch sizes and minimum Work In Process (WIP). Workers would operate their cleaning stations in a continuous-production environment



MAEPNC RECOMMENDED LAYOUT - BUILDING 360
FIGURE 8.3.1.1.1-1

where conveyors bring the parts to the worker, rather than expecting the worker to go and find the parts. This will produce the best utilization of equipment and workers and keep flow time to a minimum.

This layout also includes visual inspection stations at key points on each process. These stations include a "rework path" for parts failing inspection which will route them back through the cleaning process if required. These rework paths can also be shunted to carrousel conveyors should MAE engineering wish to capture and study failed parts as part of a process control effort. These inspection stations do not have to be operated at all times.

Counters will be built into the conveyors at key points, to capture data on work volume, holding/flow times and rework volumes. In addition each line work station will be equipped with an "andon light" switch, allowing any worker to stop the line when a problem is observed.

The operation of each line in the proposed layout is described below. Each line is illustrated by an expanded figure showing the layout of that portion of the entire layout:

LINE 1 - VIBRATION CLEANING - This line cleans small, highly carbonized parts (primarily vanes and blades) which are handled in batches and cannot be cleaned by CO_2 blasting.

- These parts first undergo a chemical cleaning and are then unloaded manually at the end of the chemical line.
- The unloading workers stack the parts onto the carrousel conveyor which carries them past the vibration cleaning station. When parts are being loaded faster than the vibration station can off-load them, they will continue to circle on the carrousel (being counted each time around). If either the loading workers or the vibration station worker sees the conveyor becoming overcrowded, they can stop the line and light their andon light - requesting a Supervisor's assistance.

- The vibration station worker unloads the carrousel and loads batches of parts into the vibration cleaning machines (currently owned by MAEPNC). When a batch has finished he unloads them onto the removal conveyor. His job is to keep the carrousel empty, not to keep the vibration machines full. He can inspect parts himself and rework those which need it, or let the line inspector perform this task.
- Once the parts are on the removal conveyor, they are carried through an automatic steam booth which sprays the parts with steam to remove any vibration cleaning media which may be trapped in the parts' geometry.
- From the steam booth, the parts are conveyed past an inspection station and onto the next RCC. The inspector (if one is assigned a the time) will inspect some or all of the parts visually. Any which do not pass are returned to the carrousel by the reject belt.

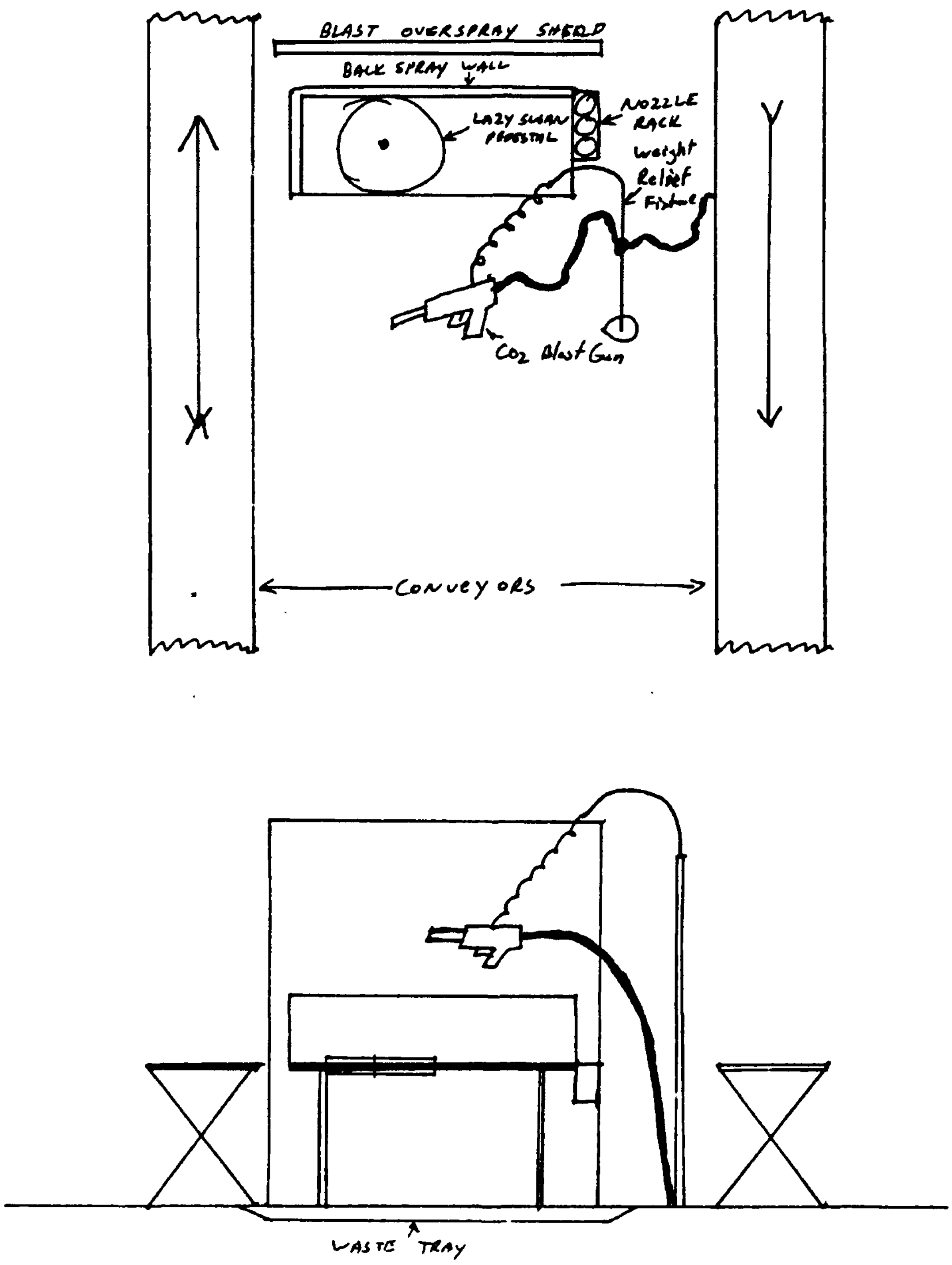
LINE 2 - LARGE PART BLASTING - This line cleans large parts which require dry grit blasting to remove soils bonded to the surface. Parts which first require chemical cleaning are loaded onto the induction conveyor at the end of the chemical line. Those parts which do not require preliminary chemical cleaning are loaded onto the induction conveyor from the existing conveyor coming from the engine disassembly area.

- The induction conveyor carries the parts onto the Line 2 carrousel, where they circle (again, being counted) awaiting blasting.
- The operators at each of the three large blasting stations (currently owned by MAEPNC) select parts from the carrousel on their right, place these parts into their blast cabinet and blast the parts clean. Because these are the largest parts in the system, the carrousel is placed to the right of the blasting stations. As most people are right-handed, this will facilitate moving the larger parts.
- When each part has been blasted, the operator removes the part from the cabinet, inspects it, and places it on the removal conveyor to the left. The operator's job is to keep the carrousel empty.
- The removal conveyor carries the parts through an automatic steam station similar to that used in the vibration line. After steam cleaning, the parts are conveyed past an inspection station (with reject belt) and out of the RCC.

LINE 3 - SMALL PART BLASTING - This line cleans smaller parts which require dry grit blasting. It uses four small blast stations (currently owned by MAEPNC) and is virtually identical to Line 2 in operation. If necessary, different blast media may be used in one or more stations. If production requirements are at a low point, some stations may not be used. The operators can provide their own quality inspections, in addition to those which may be provided by the line inspector.

LINES 4 AND 5 - CO_2 BLASTING - This double line handles the bulk of the MAEPNC workload, including everything currently cleaned on the hand cleaning line (F100 Titanium parts). The function of both lines are identical (although mirror-imaged). Both lines share a single removal conveyor.

- Parts are loaded onto the induction conveyors from the existing conveyor coming in from the engine disassembly area.
- These parts are conveyed through automated CO_2 pellets blasting from all sides (including below, through the conveyor rollers). This step is designed to remove most of the soil from the outside of the part. It is not designed to completely clean each part. Each station delivers CO_2 pellets through multiple nozzles arranged in a pattern to be determined by experimentation. The pellets will be provided by a CO_2 blast unit dedicated to the station. A holding net may be required to keep lighter parts in place during the automatic blasting. The blasting may be continuous or triggered by a part entering the station, depending on production rates.
- After leaving the automatic CO_2 blasting stations, the parts will be carried to carrousel conveyors. Workers at each of three manual CO_2 blasting stations (per line) will remove the parts from the carrousel, place them on the blasting stand, blast them clean with hand-held CO_2 blasting guns. The nozzles for these guns can be exchanged in seconds, to allow different types of parts to be cleaned. If necessary, one or more stations can be dedicated to a certain part or type of part. For example, one station may be tasked to blast the inside of all cylindrical parts. CO_2 pellets for each of the three stations on a line will be provided by a single CO_2 blast unit. Figure 8.3.1.1.1-2 shows a preliminary design for the manual CO_2 blast stations, as recommended by the MDMSC human factors specialists.



20909

CO_2 BLAST STATION LAYOUT
FIGURE 8.3.1.1.1-2

- After blasting each part clean, the CO_2 blast station workers will load the parts on a common removal conveyor which will transport the parts past a pair of inspection stations and out of the RCC.

This entire layout is designed to be smoothly flowing, with a minimum of waiting, batching, or manual parts handling. Whenever possible, it is designed to use equipment that is already located in MAEPNC. It includes process control points - (inspection stations) where process quality can be monitored, but does not remove the individual workers' ability/responsibility to control their own process quality, through in-process inspection (first time quality) and the use of the andon light to stop the line should a problem occur.

Although, at full production the entire line will require 25 workers (including inspectors), it can be run with much fewer people by not manning all stations. This will give MAEPNC management a great deal of flexibility in scheduling workers to meet variable workloads.

8.3.1.1.2 Potential Improvement

The improvements offered by this focus study are the reduction in flow time in MAEPNC and the elimination of 267 tons of hazardous waste each year.

The reduction in flow time will result in reduced WIP inventories. Because MDMSC was tasked to evaluate only MAEPNC, it is impossible to determine the real value of this improvement. The degree of value is dependent on the level of constraint MAEPNC places on the MAE engine repair process. MDMSC assumes that the Air Force choice of MAEPNC for an Industrial Process Improvement (IPI) task order indicates that the RCC is a bottleneck in the MAE process, but cannot estimate the value of reduced flow times/WIP without additional information.

The reduction of hazardous waste is much easier to quantify. The savings calculations are based on waste stream data provided by MAQ (including manifest costs for wastes shipped off-side) and a previous study (on reducing in-house waste treatment costs through filtration technology) performed by MAE engineers. In addition to the reduced costs of disposal and replacement chemicals, the reduction of hazardous waste has an intrinsic value. It reduces the destruction of the environment and improves life for all Americans. Current public and political trends may make this the most significant benefit of all.

The savings generated by this recommendation are estimated at 2/3 of current waste disposal costs (9 chemical lines reduced to 3):

WASTE DISPOSAL

Vendor (off-site)	$29,000
In-House (including rinse water)	$628,000
Total	$657,000

Details of these estimates can be found in Section 9.1 of the DDB.

The investment and additional operating costs generated by this recommendation are estimated as follows:

Non-Recurring

CO_2 Blasting Equipment

2 3-nozzle units @ $330K ea.	=	$660,000
2 2-nozzle units @ $280K ea.	=	$560,000
2 flow splitter units @ $50K ea.	=	$100,000
1200 feet of powered conveyor with assorted switching/routing hardware	=	$300,000
3 automatic steam stations (using steam equipment already in MAEPNC)	=	$30,000

Facilities work: Laying sub-floor over current area floor, moving blasting/vibration equipment, removal of tanks and assorted plumbing, transferring chemicals from Lines 4, 7, and 8 to 1 - 3. = $350,000

Implementation Planning (MDMSC)	=	$215,000
TOTAL	=	$2,215,000

Recurring

320,000 lbs/year CO_2 x $ .025/lb	= $8000/year
TOTAL	= $8000/year

At a non-discounted rate, this change will break even at 3.4 years.

8.3.1.1.3 Risk Assessment

The risks associated with this study are relatively small. The primary areas of risk are: Technical - that the CO_2 blast process or other technologies will not produce the effects predicted; or, Administrative - that the costs of implementing the new processes will cost more than MDMSC has estimated or the savings will be lower than estimated.

The technical risk is relatively small. All the equipment/technology proposed is off-the-shelf and is already used successfully elsewhere. The most significant example of this is found at Delta airlines. MDMSC's assessment (performed by the MDMSC commercial aviation specialist) found that Delta is currently operating an automated CO_2 blasting line to strip/clean aircraft wheels prior to Fluorescent Penetrant Inspection (FPI). The process involves a powered conveyor which carries the parts through automatic blast processes. While the parts volume is lower (100 wheels/day) than that found in MAEPNC, the concept is very similar and Delta engineers report satisfaction with the process. The powered conveyors are completely standard and already in use throughout SA-ALC.

The administrative risk is somewhat more difficult to quantify but still appears minimal. The capital costs are based on vendor catalog prices and quoted prices and should be extremely reliable. The facilities estimates are less reliable but are primarily Air Force costs (facilities work should be performed by SA-ALC personnel or under their supervision) and, thus, Air Force facilities personnel can provide more detailed estimates if required. The risks of under estimation are largely offset by the possibility that much of the conveyor equipment can be obtained as surplus from other depot areas within the command.

8.3.1.1.4 Duration and Level of Effort

Under this focus study MDMSC proposes to work with the vendors of the new hardware to determine:

- Feed rates, layout, and conveyor design required to support the new process.
- Nozzle types, arrangement, CO_2 plumbing designs, and work station design necessary to optimize CO_2 blasting process.
- Perform a make/buy analysis to determine whether the steam stations should be built in-house or by an outside contractor.

In addition, MDMSC proposes to:

- Perform a detailed evaluation of the workload to determine applicability of CO_2 blast process on a part-by-part basis. This will result in a capacity analysis which will determine actual capital investment requirements.
- Perform motion-time studies at each station to determine manpower requirements and evaluate work station design.
- Produce scaled layout diagrams for facilities personnel to use during the implementation phase.

Work with MAE management to establish a changeover plan, describing MAE operations during the implementation phase.

The deliverable product of this focus study will be a Contract Summary Report describing the proposed change in sufficient detail to allow SA-ALC personnel to completely manage the implementation with a minimum of MDMSC assistance.

MDMSC estimates the requirements for this task as follows:

<u>Labor</u>

1 MDMSC Industrial Engineer for 960 hours @ $62.40	=	$59,904.
1 MDMSC Mechanical Engineer for 960 hours @ $62.40	=	$59,904.
1 MDMSC Human Factors Spclst. for 320 hours @ $62.40	=	$19,968.
1 MDMSC Procurement Spclst. for 160 hours @ $80.00	=	$12,800.
St Louis Support for 480 hours @ $62.40	=	<u>$ 29,952</u>.
TOTAL	=	$182,528.

Travel

2 engineers x 130 days @ $50./day ea.	=	$18,000.
1 Human Factors Spclst. x 60 days @ $76./day	=	$ 4,560.
Short term travel	=	$ 10,000.
TOTAL	=	$ 32,560.
GRAND TOTAL	=	$215,088.

8.3.2 Quick Fixes

This paragraph summarizes MDMSC's Quick Fix recommendations. These are recommendations which can be implemented in less than six months, with a capital investment of $200,000 or less. Details of these suggestions, including cost analysis, can be found in the Task Order 14 Quick Fix Plan.

MDMSC's Quick Fix recommendations are summarized as follows:

- Elimination of Wrapping - Fragile parts are currently wrapped in plastic bubble wrap to prevent damage during handling. This wrapping process is labor-intensive and uses large quantities of bubble wrap. Production reports that they have ordered reusable prefabricated bags and boxes to hold these parts. While MDMSC has observed some of the bags and boxes in use, most parts are still bubble wrapped individually, by hand. During the course of this Task Order (four months), the bags and boxes on order have not arrived. This quick fix describes MDMSC's recommendation to fabricate containers in-house, while MAEPNC is waiting for the prefabricated containers to be delivered. MDMSC estimates that this recommendation will save MAEPNC $69,425 in direct labor per year.
- Mechanical Agitation of Chemical Cleaning Tanks - The tanks in the automated cleaning line are currently agitated by compressed air blown into the tanks. This method does not produce adequate agitation. In addition, it introduces additional oils and dirt into the tank, accelerates solution oxidation, and causes foaming in the tanks. Standard commercial mechanical agitation equipment will not fit in the tight clearance between the cleaning baskets and the edge of the tank. Other designs, such as the side-mounted prop agitators used at OC-ALC, are expensive to install and may cause severe maintenance problems. This quick fix describes an MDMSC-designed mechanical agitation system

which can be locally manufactured and will fit the current tank/basket design. MDMSC's chemical engineer estimates that mechanical agitation will increase the efficiency of the cleaning tanks by an average of 30%. In addition, the agitation can be applied to the acid tanks, which are not currently agitated. MDMSC estimates that this recommendation will have a value to MAE of approximately $1,008,000 in reduced WIP inventory cost annually.

- Combine Cleaning Lines 1, 2, and 6 - As described in Paragraph 8.2.1.3.1 of this report, automated cleaning Lines 1, 2, and 6 can be combined (at current workloads), without significant effect to flow times or WIP levels. This recommendation will save an estimated 2400 square feet of floor space in the automated cleaning area of Bldg. 360.

8.3.3 Other Observations

This paragraph contains recommendations which MDMSC believes would be real process improvements but cannot be adequately quantified for inclusion as a Quick Fix or Focus Study.

8.3.3.1 Cleaning Chemical Ordering Procedures

MAEPNC currently orders most cleaning chemicals under generic MIL-SPECS. This generally means that PMK (procurement) purchases the least expensive chemicals available. The same is true of those chemicals obtained from the Defense Logistics Agency (DLA). Many of the chemicals obtained are poor choices for the cleaning applications and could be replaced with superior (though more expensive) proprietary compounds. The MAEPNC production managers complain that this situation causes significant quality problems, requiring substantial additional rework in some cases (no actual rework figures are tracked in MAEPNC). These managers explained that they could not specify the chemicals they want to use, because their technical data calls out only generics.

The MDMSC chemical engineer concurs that many of the compounds currently in use in MAEPNC should be replaced with higher-quality commercial brands. An MDMSC chaired meeting with the MM engineers responsible for managing the MAEPNC cleaning process indicated that, while specifying particular chemicals was difficult under current U.S. Government procurement policy, it could possibly be done if

MAEPNC requested a change. The cleaning line at OC-ALC, for example, has developed a specification procedure that allows both the Tinker AFB procurement office and DLA to order high-quality chemical compounds, even where the cost is higher than the generics. Details of this arrangement, along with points of contact in the OC-ALC cleaning line, Tinker AFB procurement, and DLA, have been provided to MAEPNC management, and are included in Section 5.0 of the DDB.

The MM engineers noted that the first step towards implementing such a program at SA-ALC would be a letter from MAE to MM, describing the problem and requesting help in changing/improving the cleaning process. To date, MDMSC has been unable to identify any such letter which has ever been written.

MDMSC recommends a Process Action Team (PAT) be formed with members drawn from MAE Engineering, MM, PMK, DS, and MAEPNC. The goal of this team would be to document the current problem and devise a program (similar to that at OC-ALC) which will allow MAEPNC to purchase the best (highest quality vs lowest cost) cleaning chemicals needed to support their process. Details of this situation are described in the engineering notes found in Sections 5.0 and 10.0 of the DDB.

8.3.3.2 Shut-off Valves on Individual Steam Lines

Currently, the steam lines which heat the cleaning tanks in MAEPNC cannot be turned off at each tank. The only shut-off valves are at the end of each line, with all tanks plumbed in series. As a result, when maintenance is required on a tank and the steam must be shut- off, all the tanks much be shut-off. This causes all processes on the line to be shut down while a single tank is repaired.

MDMSC recommends that each tank be fitted with a shut-off valve in parallel to the central line. This will allow a single tank to be repaired while the others remain in operation. While the costs of this change are undetermined, they can be minimized by incorporating the change using SA-ALC craftsmen, during tank overhauls or as part of an unscheduled maintenance action.

8.3.3.3 Location of Conveyor Switches

There is currently only one switch to operate the powered conveyor line in MAEPNC. Its location is shown in Figure 8.3.3.3-1 as Point "A". This switch is extremely inconvenient for workers at the other end of the conveyor line - requiring them to run/walk the length of the line to shut it down if necessary.

MDMSC recommends three additional switches be installed at Points "B" of Figure 8.3.3.3-1. This will eliminate the trip from one end of the conveyor line to the other and remove a minor burden from the MAEPNC workers.

8.3.3.4 Elimination of Safety Wiring in the Cleaning Process

Some engine parts must not be allowed to touch each other during chemical cleaning. To prevent this, MAEPNC workers fasten each part to the cleaning basket with steel (safety) wire. This process is labor-intensive and time consuming.

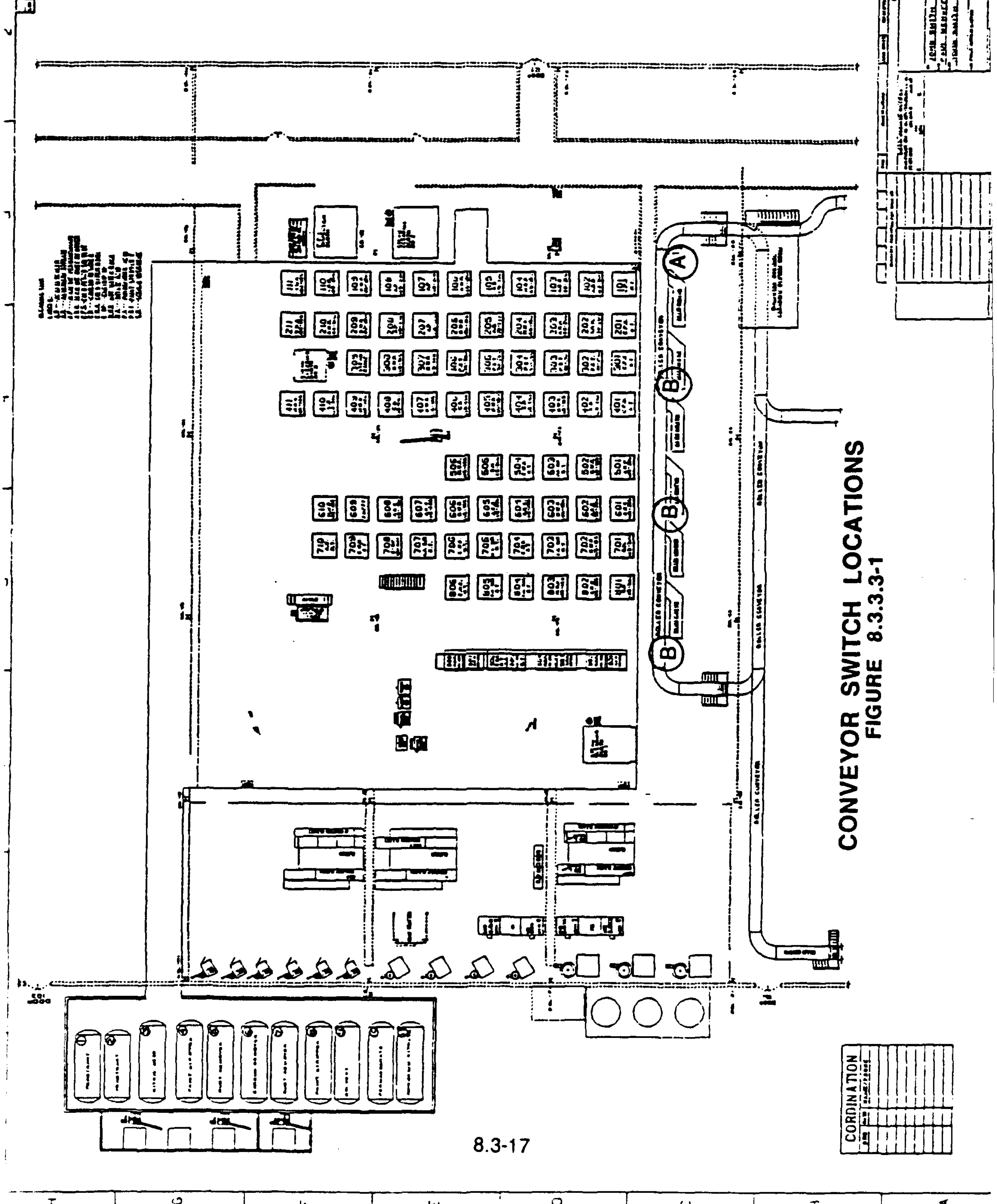
MDMSC recommends that special fixturing be provided so that the parts may be kept separated with little extra effort. This can be accomplished several ways:

- special compartmentalized baskets.
- dividers that can be quickly installed in the baskets currently being used.
- providing specially designed fasteners/cables that attach parts to the baskets. They could remain with the basket or be removed.

Observation and interview determined it required an average of fifteen minutes to wire seven parts to the basket. (Data from the T56 gear box area and assumed to be representative of other areas). 15 minutes/7 parts = 2.1 minutes per part potential savings. As MDMSC was unable to determine how many of these parts must be wired in a year, no estimates are available for the potential savings of this recommendation.

8.3.3.5 Use of Scheduling Boards in MAE

Parts currently flow through much of the MAE production process (including cleaning in MAEPNC) without any identifiable schedule, and without any flow times being tracked by anyone. As a result, no one was able to provide MDMSC with data on flow times or estimates of actual inventory levels. This lack of scheduling will preclude the development of any real Just-In-Time (JIT) flow through the MAE process.



CONVEYOR SWITCH LOCATIONS
FIGURE 8.3.3.3-1

As parts are not scheduled or tracked, shortages periodically occur in the engine assembly area. These shortages trigger the expedition of "hot" parts through MAEPNC and other areas. This disrupts production, delaying the progress of other parts and consumes extra manpower in searching for and handling the expedited parts. Because no records are kept on the incidence of this situation, MDMSC is unable to quantify the magnitude of the problem.

As an expedient solution to the problem, MDMSC recommends MAE establish "shadow boards" where completed engine parts can be stored/hung while they await assembly. With this arrangement (rather than the current system of storing these parts in the stacker or batched in in-process storage points), anyone could immediately see, at a glance, when an engine is ready for assembly, or what parts are still missing. For parts which must be tracked by serial number, the disassembly personnel could fill out a tag with the engine and part serial numbers. This tag could be placed in the appropriate position on the shadow board and only removed when it was replaced by the required part. Some parts could be hung on boards, while others would be put in drawers or on labeled areas of floor. The idea is that all the parts needed to assemble an engine are stored in one highly-visible location. This will allow the assembly step to "pull" engine parts through the system in a timely fashion, rather than the current "push" from disassembly. The long term effect will be a more efficient flow of parts, with reduced WIP inventories and shortened flow times. This change would be the first step towards establishing a JIT flow in MAE.

This recommendation was developed by the United Airlines engine maintenance facility in San Francisco. The MDMSC commercial aviation specialist reports that United Airlines actually places bags of disposable/replaceable bench stock items (nuts, bolts, glue, filter, etc.) on the shadow boards as well as engine parts. Production does not have to depend on complex computer systems or large scheduling departments to tell them when they are ready to assemble an engine (or what they need to do to get ready to assemble).

MDMSC strongly recommends that these boards be set up for one engine model, to test the applicability of this idea to MAE. If floor space is a problem, use the space freed by implementing the line combination recommendation described in Paragraph 8.3.2 of this report and the Task Order No. 14 Quick Fix Plan.

APPENDIX A

LIST OF ACRONYMS AND ABBREVIATIONS

LIST OF ACRONYMS AND ABBREVIATIONS

AF	AIR FORCE
AFLC	AIR FORCE LOGISTICS COMMAND
ALC	AIR LOGISTICS CENTER
ANOVA	ANALYSIS OF VARIANCE
ATP	ACCEPTANCE TEST PROCEDURE
CDRL	CONTRACTOR DATA REQUIREMENTS LIST
CO_2	CARBON DIOXIDE
DAC	DOUGLAS AIRCRAFT COMPANY
db	DECIBELS
DDB	DATABASE DOCUMENTATION BOOK
DLA	DEFENSE LOGISTICS AGENCY
DS	DIRECTORATE OF SUPPLY
ERAU	EMBRY-RIDDLE AERONAUTICAL UNIVERSITY
FDA	FOOD AND DRUG ADMINISTRATION
FIFO	FIRST IN - FIRST OUT
FPI	FLUORESCENT PENETRANT INSPECTION
FS	FOCUS STUDY
GTE	GAS TURBINE ENGINE
IPI	INDUSTRIAL PROCESS IMPROVEMENT
JIT	JUST IN TIME
MCAIR	MCDONNELL AIRCRAFT COMPANY
MDMSC	MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY
MISTR	MAINTENANCE OF ITEMS SUBJECT TO REPAIR
MTBF	MEAN TIME BETWEEN FAILURES
MTTR	MEAN TIME TO REPAIR
OC-ALC	OKLAHOMA CITY AIR LOGISTICS CENTER
PAT	PROCESS ACTION TEAM
PC	PERSONAL COMPUTER
PM	PREVENTIVE MAINTENANCE
QF	QUICK FIX
RCC	RESOURCE CONTROL CENTER
ROM	ROUGH ORDER OF MAGNITUDE
S/N	SIGNAL TO NOISE
SA-ALC	SAN ANTONIO AIR LOGISTICS CENTER
SOW	STATEMENT OF WORK
UDOS 2.0	UNIVERSAL DEPOT OVERHAUL SIMULATOR, VERSION 2.0
USAF	UNITED STATES AIR FORCE
WCD	WORK CONTROL DOCUMENT
WG	WAGE GRADE
WIP	WORK IN PROCESS

INDUSTRIAL PROCESS IMPROVEMENT
ENGINEERING SERVICES
PROCESS CHARACTERIZATION
TASK ORDER NO. 14

VOLUME V
SA-ALC

QUICK FIX PLAN
16 NOVEMBER 1990

CONTRACT NO. F33600-88-D-0567
CDRL SEQUENCE NO. 14A010

MCDONNELL DOUGLAS
McDonnell Douglas Missile Systems Company
St. Louis, Missouri 63166-0516 (314) 232-0232

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

8.0 SAN ANTONIO AIR LOGISTICS CENTER (SA-ALC)

As a result of the process characterization of MAEPNC at the SA-ALC, MDMSC has developed three process improvement recommendations which are presented as quick fix opportunities. They are summarized in Table 8.0-1. This plan describes each quick fix in detail and shows the calculation of cost savings and inventory reduction values.

SA-ALC QUICK FIX RECOMMENDATION SUMMARY (TASK ORDER NO. 14)
TABLE 8.0-1

MDMSC RECOMMENDATION	IMPACT	BUDGET SAVINGS	COST AVOIDANCE			INVESTMENT COST
			FLOW TIME REDUCTION	WIP INVENTORY REDUCTION	FLOOR SPACE REDUCTION	
REPLACE CURRENT HAND WRAPPING OF PARTS WITH PREFAB PACKAGING	ELIMINATE THE DIRECT LABOR COSTS ASSOCIATED WITH HAND WRAPPING	$69,425	0 DAYS	$0	0 SQ. FT.	$0
INSTALL MDMSC-DESIGNED MECHANICAL AGITATION SYSTEM ON CLEANING TANKS	INCREASE CLEANING ACTION BY 30% OVER CURRENT SYSTEM	$0	8 HRS. (AVG)	$1 MILLION (ANNUALLY)	0 SQ. FT.	$25,000
COMBINE CLEANING LINES 1, 2 AND 6 TO INCREASE RESOURCE UTILIZATION	ALLOWS ELIMINATION OF 2 CHEMICAL CLEANING LINES	$0	0 DAYS	$0	2400 SQ. FT. BLDG. 360	$0
TOTALS		$69,425	8 HOURS	$1 MILLION	2400 SQ. FT.	$25,000

20762C

8.1 QUICK FIX OPPORTUNITY TO IMPROVE WORKERS EFFECTIVENESS THROUGH ELIMINATION OF WRAPPING/ UNWRAPPING OF PARTS BY PROVIDING A MORE EFFICIENT METHOD OF PROTECTING PARTS DURING TRANSIT

Ring-type parts which require special protection during moves are normally wrapped with strips of plastic bubble wrap, then taped. When the parts reach the next step of the cleaning process the wrapping is removed, then replaced for the next move. This process is repeated at each cleaning process. The removed wrapping is often discarded and new material is used. Envelopes made from bubble wrap and "pizza box" type containers are being used, when available, and more of each have been ordered, but their use is still very infrequent.

The time spent wrapping and unwrapping parts is nonproductive. This process not only reduces the time the worker has to clean parts but also adds a large amount of plastic to the waste stream requiring disposal. The wrapped parts do not stack well and tend to slide off the pile, potentially causing damage to the part or taking time to restack. One operator reported restacking a pallet of parts six times. They degenerated into piles each time.

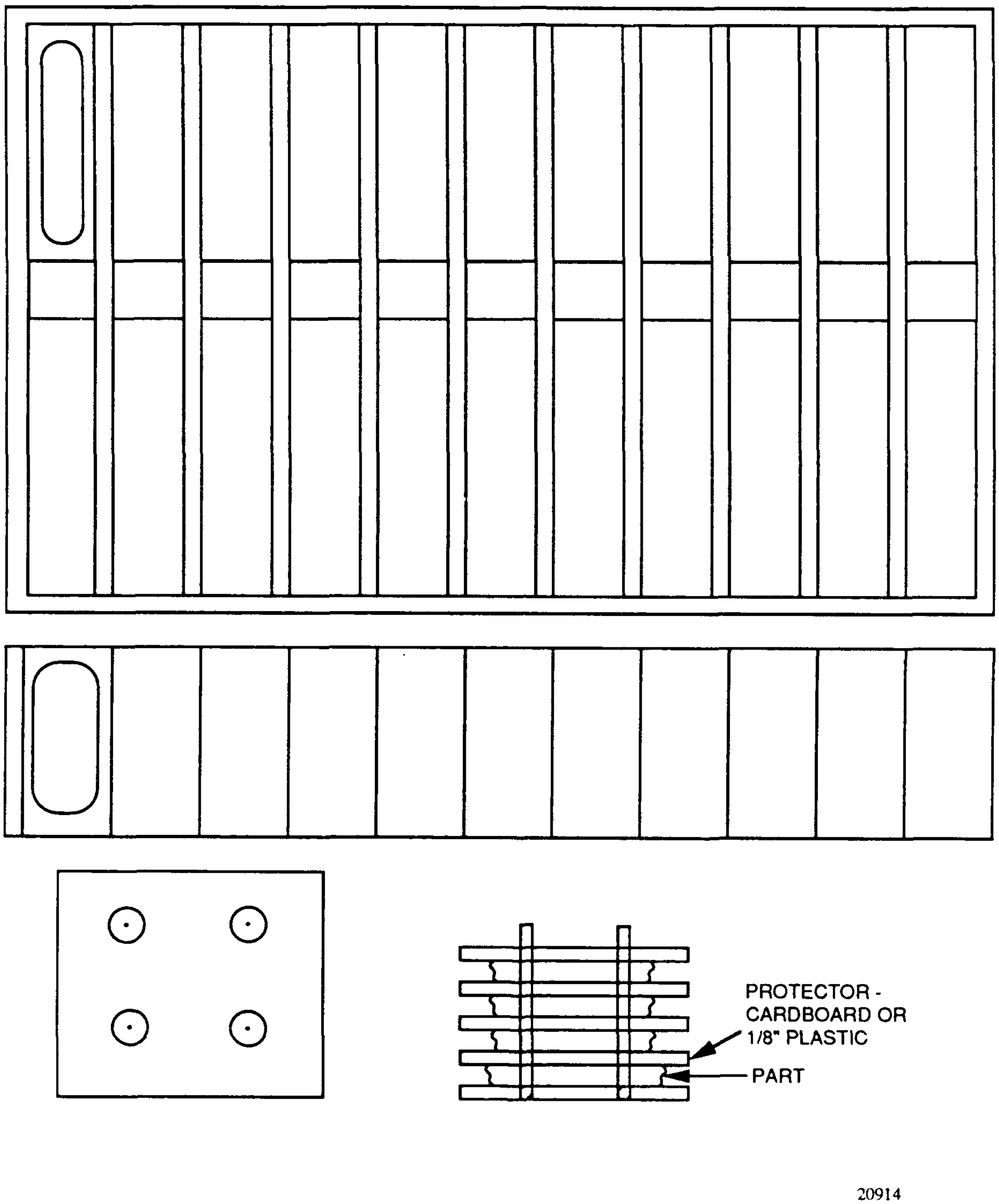
Until the envelopes and "pizza box" type containers now on order are received there are other temporary methods that can be used:

- Make an envelope from the plastic bubble wrap and tape. Use and reuse.
- Make an envelope from corrugated paper and tape. Use and reuse.

The following methods should also be considered as possible permanent solutions for protecting parts:

- Build special handling containers for high volume parts.
- A box with compartments to protect parts. Figure 8.1-1 shows such a box.
- A base and pipe unit, such as shown in Figure 8.1-1.

It is important that the containers, boxes, etc. be sent back to disassembly from the first cleaning station and the containers, boxes, etc. from inspection be sent back to the to cleaning stations. Clean parts should not be put into dirty containers.



WRAP DRAWING
FIGURE 8.1-1

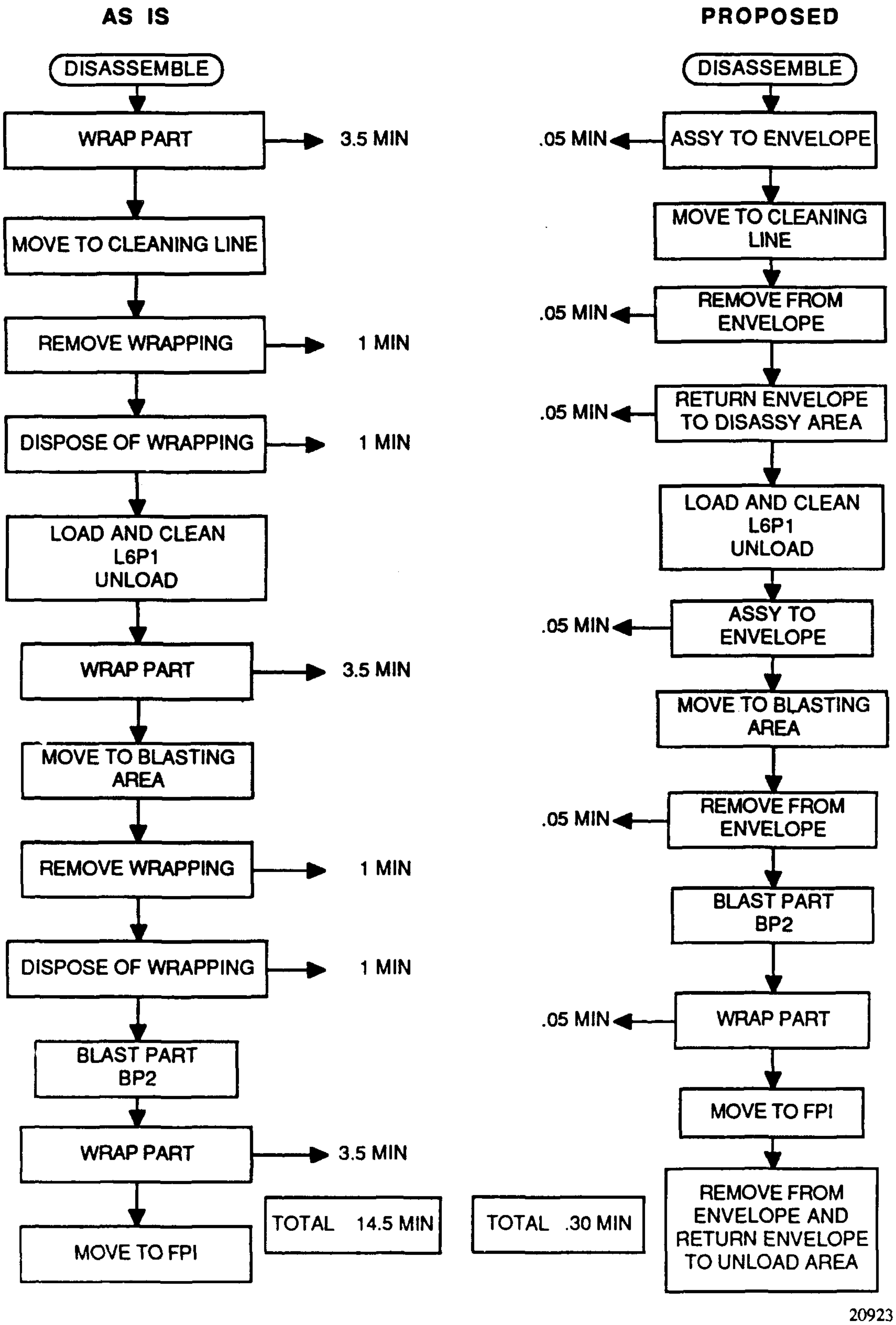
MDMSC estimates the value of the labor savings generated by this recommendation based on the assumption that 50% of the parts requiring hand cleaning or blasting operations are special protection parts. Fifty percent of these are being wrapped and unwrapped.

Observation and interview determined it required an average of six minutes to wrap parts and three minutes to remove and discard the wrapping. This information has been put into the UDOS model. The manpower required by the wrap/unwrap operation is 61950 hours. The savings resulting from using envelopes or other efficient ways of protecting parts is <u>4394</u> hours per year or $69,425.

4394 x $15.80= $ 69,425

There is also a reduction of flow time, and work in process (WIP) as well. It is difficult to assign dollars to savings in these areas. Figure 8.1-2 shows the details of labor savings. Table 8.1-1 shows the results of the UDOS 2.0 experiment used to evaluate/quantify this recommendation.

The materials needed for the temporary methods are now available in the area. Cost of the new method will approximately equal the costs of the present method because, although less material will be required, some man hours will be required to make the envelopes. MDMSC recommends this change in packaging be implemented immediately.



ELIMINATION OF PART WRAPPING
FIGURE 8.1-2

UDOS LABOR HOUR REDUCTION BUBBLE WRAP OPERATION
TABLE 8.1-1

		VALIDATED	NO WRAP	DIFFERENCE	% DIFFERENCE
HRS REQ	5423	22892	20030.5	2861.5	0.13
HRS REQ	7009	39058	37527.7	1530.3	0.04
	TOTAL	61950	57558.2	4391.8	0.07
FLOW HOURS	5423	41.85	14.97	26.88	0.64
	7009	8.52	5.71	2.81	0.33
STD DEV	5423	38.26	10.64	SHOWS REDUCTION IN PROCESS VARIATION	
STD DEV	7009	6.26	1.84	SHOWS REDUCTION IN PROCESS VARIATION	
AVE WIP	5423	54.5	19.4	35.1	0.64
AVE WIP	7009	4	2.7	1.3	0.33

20922

8.2 MECHANICAL AGITATION IN CLEANING TANKS

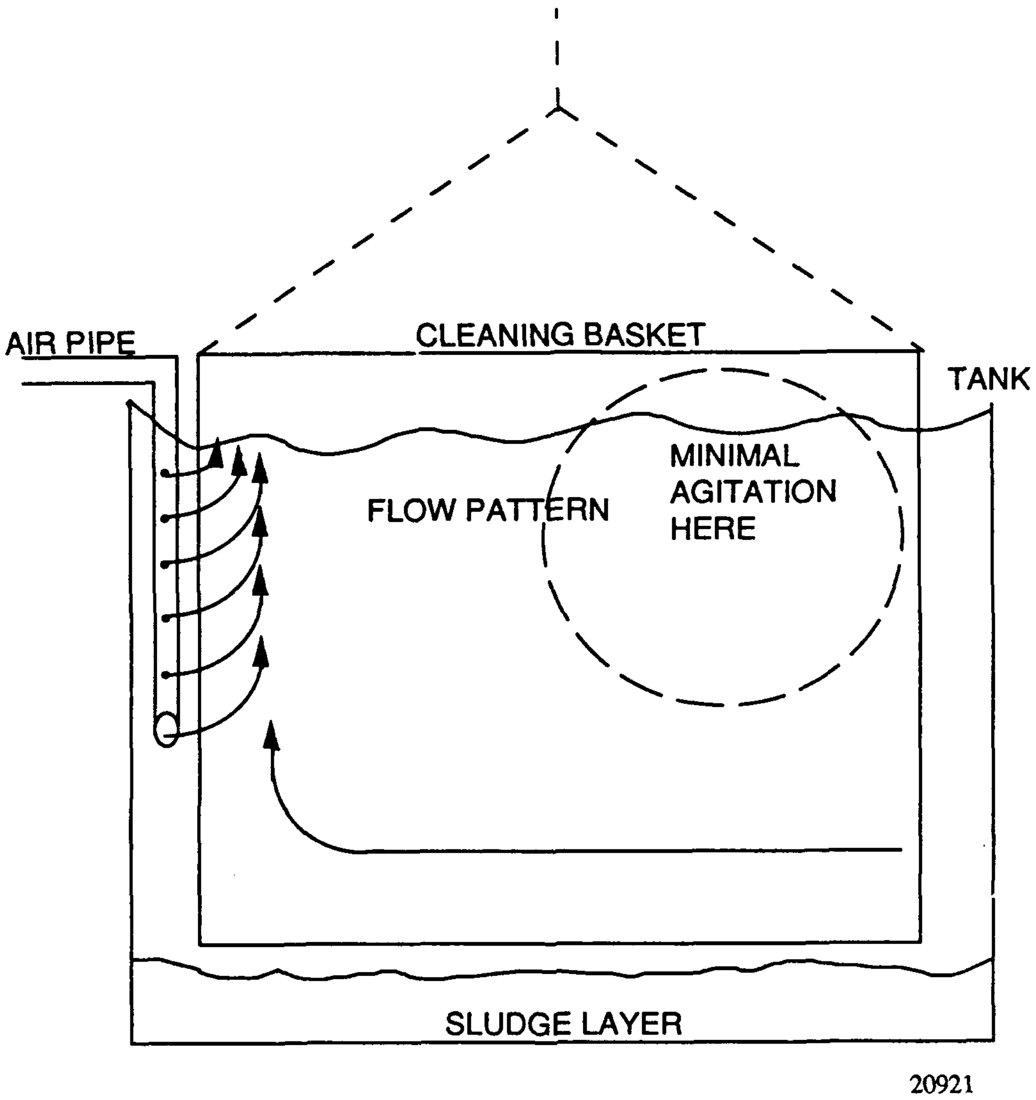
As described in the CSR, the chemical cleaning tanks in MAEPNC are agitated by compressed air blown into the tank from a pipe on one side of the tank. No sparger pipes are used because, given the clearance between the bottom of the tank and the bottom of the cleaning basket, the sparger pipes would have to lie on the very bottom of the tank. The heavy sediment layer at the bottom would quickly clog the sparger pipes and render them useless. Without these sparger pipes, the solution agitation flow pattern approximates that shown on Figure 8.2-1.

This air agitation system has several drawbacks:

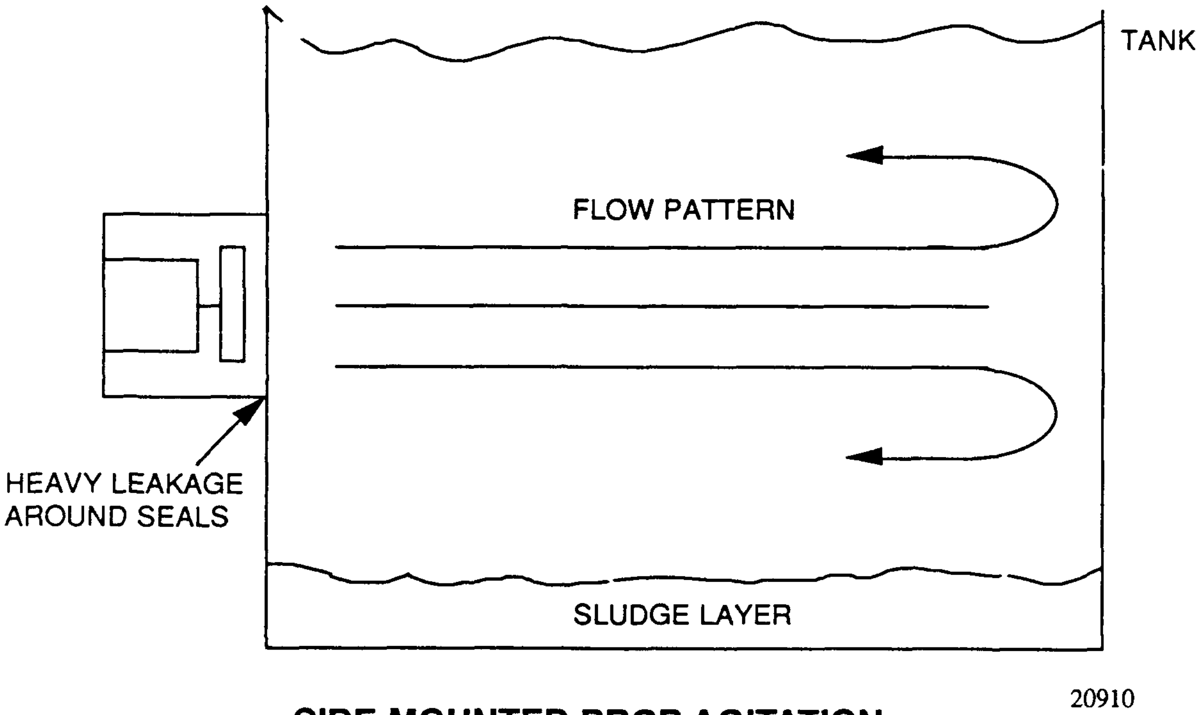
- It does not produce adequate agitation throughout the tank - especially when a cleaning basket is in the tank.
- It introduces additional oils and dirt into the solution from the shop air supply.
- It accelerates solution oxidation/breakdown.
- It causes foaming in many solutions (the acid tanks, for example, are not currently agitated at all, to preclude foaming).

While this system does provide some agitation, and is extremely cheap to install/operate/maintain, MDMSC chemical engineers believe that a mechanical agitation system would produce an average 30% increase in cleaning action (with a corresponding 30% reduction in cleaning flow time and Work In Process (WIP) inventories) and should be installed.

The extremely tight clearance between the side of the cleaning tank and the side of a cleaning basket in the tank (4 inches), precludes the use of standard off-the-shelf prop agitators. The tanks could be modified to allow agitator pumps to be installed in the sides (see Figure 8.2-2) but this design would be extremely labor-intensive to maintain and require frequent tank/agitator downtime. A system such as this is in use on the automated cleaning line at OC-ALC. The engineers there report that the agitation does improve the cleaning action significantly but the maintenance problems (leaks and constant seal replacements) render the system undesirable. MDMSC does not recommend this system.



AIR AGITATION FLOW PATTERN
FIGURE 8.2-1



SIDE MOUNTED PROP AGITATION
FIGURE 8.2-2

Other mechanical systems, such as rocker units, tumble barrels, or pump agitation would provide effective agitation, but would also require substantial capital investment. MDMSC does not recommend these systems.

MDMSC engineers have designed a simple air-driven prop agitation device that will fit in the space between the tank and basket. This device is designed for local manufacture and can be installed in each tank without modifications or facilities upgrades. The design is characterized by extreme simplicity and low maintenance requirements. It avoids the drawbacks attributed to the current air agitation and will produce the agitation flow pattern shown in Figure 8.2-3. The details of the design of this device are shown as Figures 8.2-4 through 8.2-10.

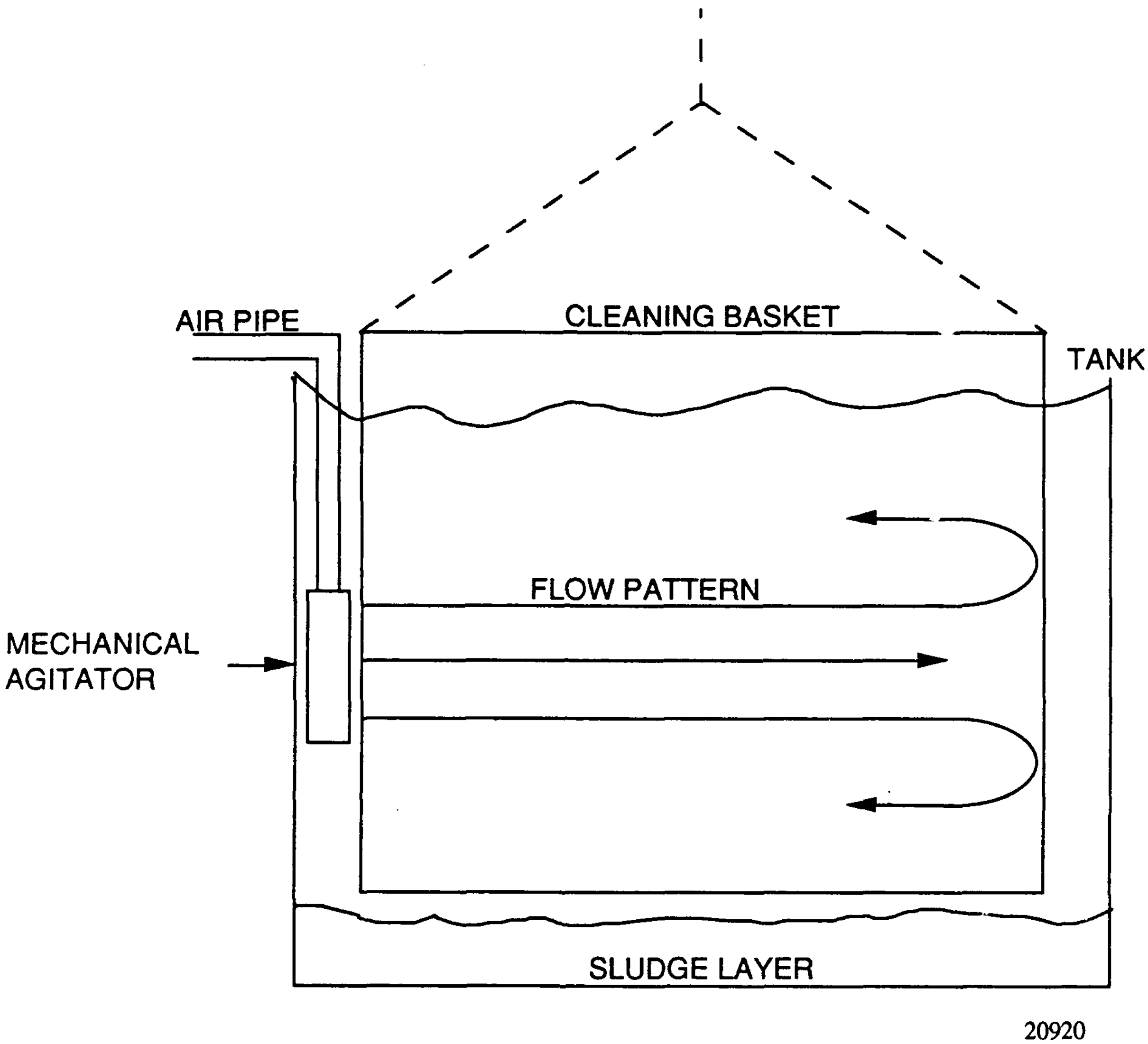
MDMSC estimates the cost of these devices at:

Labor	15 man hours to build @ $15.80/hr.	=	$ 237.00
Material	Sheet metal stock, pipe, and common hardware.		
		=	$ 100.00
	Total	=	$ 337.00 each
	$337.00 x 75 tanks in current use	=	$25,275.00

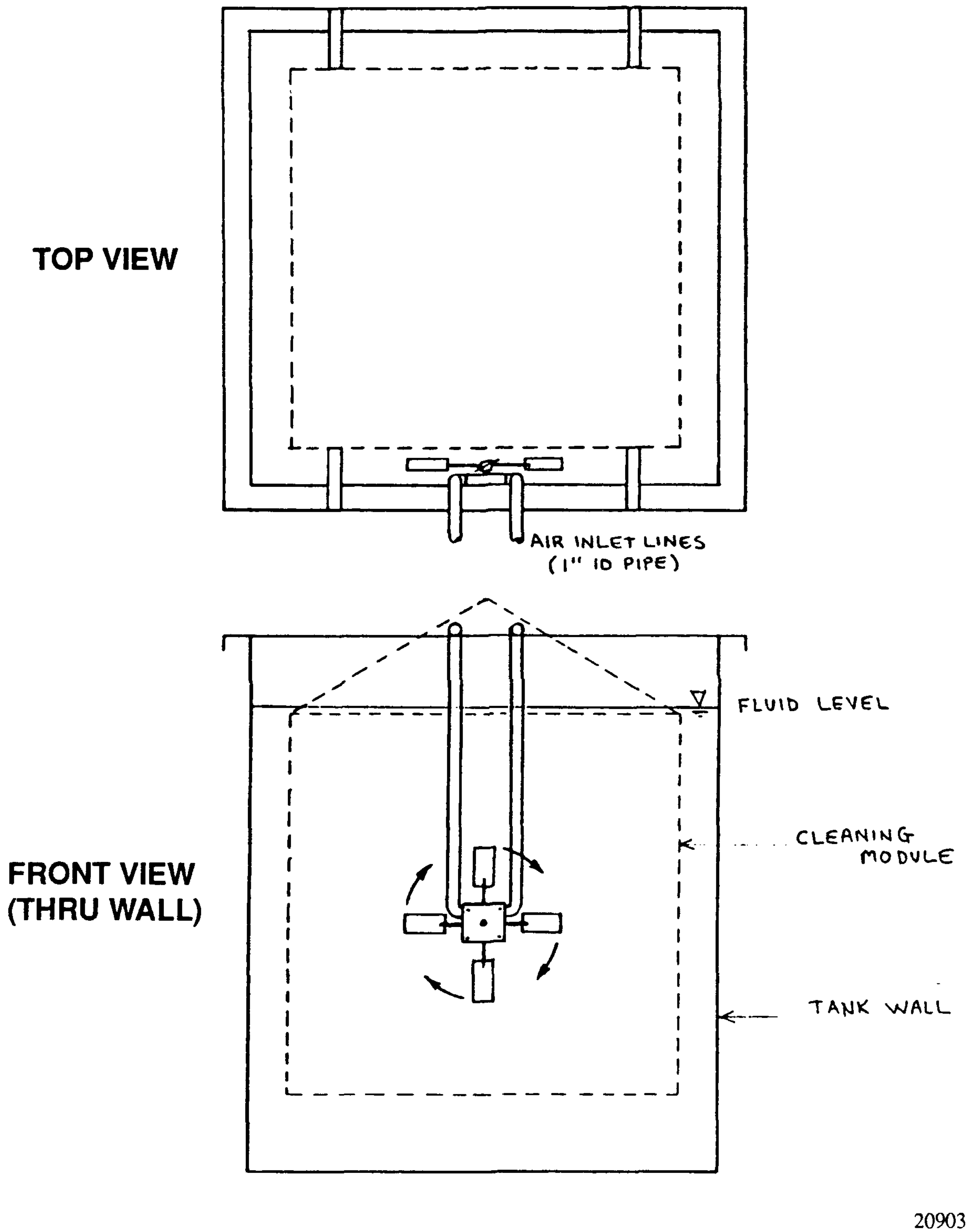
MDMSC estimates the value of the WIP inventory reduction generated by this process improvement as follows:

MAE WIP Inventory Levels

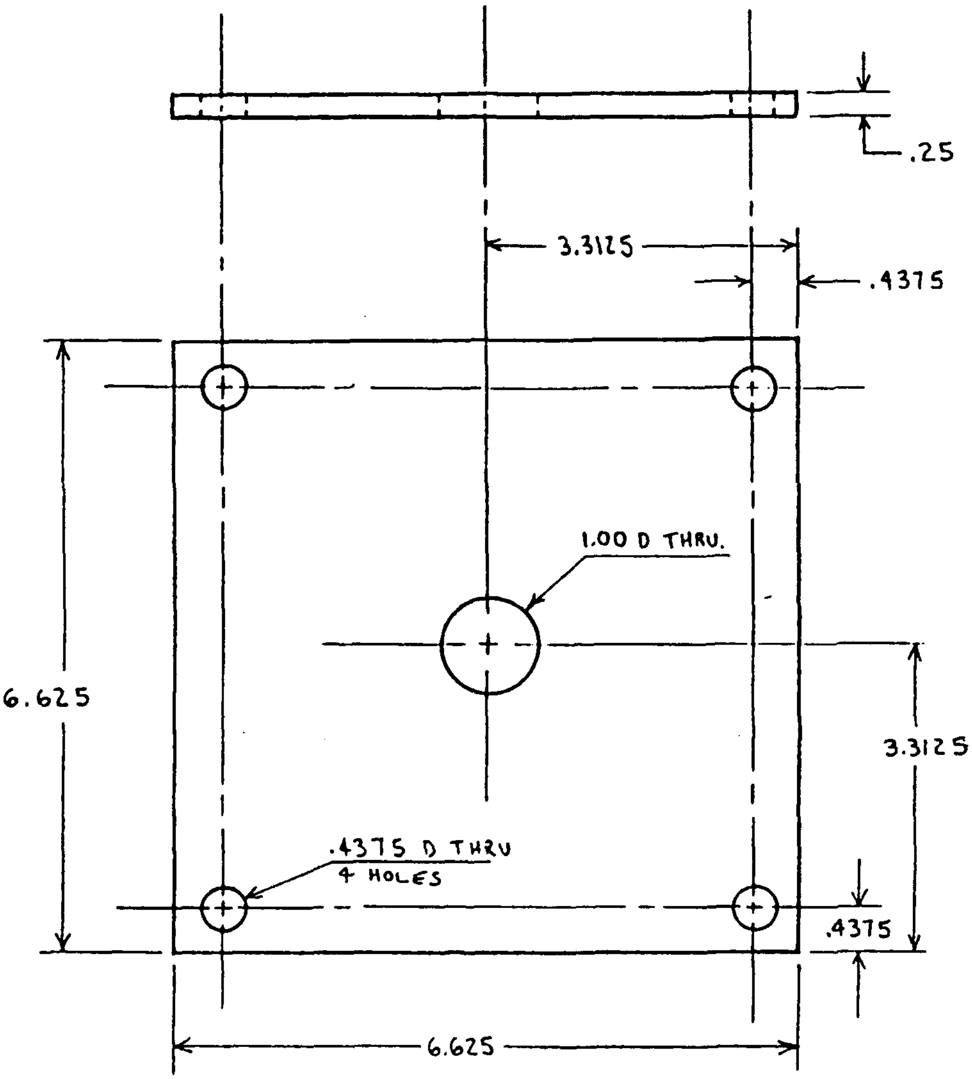
19	- T56 engines/month @ $315,000 ea.	= $5.985	million/month
1	- TF39 engine/month @ $2.4 million ea.	= $2.400	million/month
		$8.385	million/month



MECHANICAL AGITATION FLOW PATTERN
FIGURE 8.2-3



CLEANING MODULE
FIGURE 8.2-4

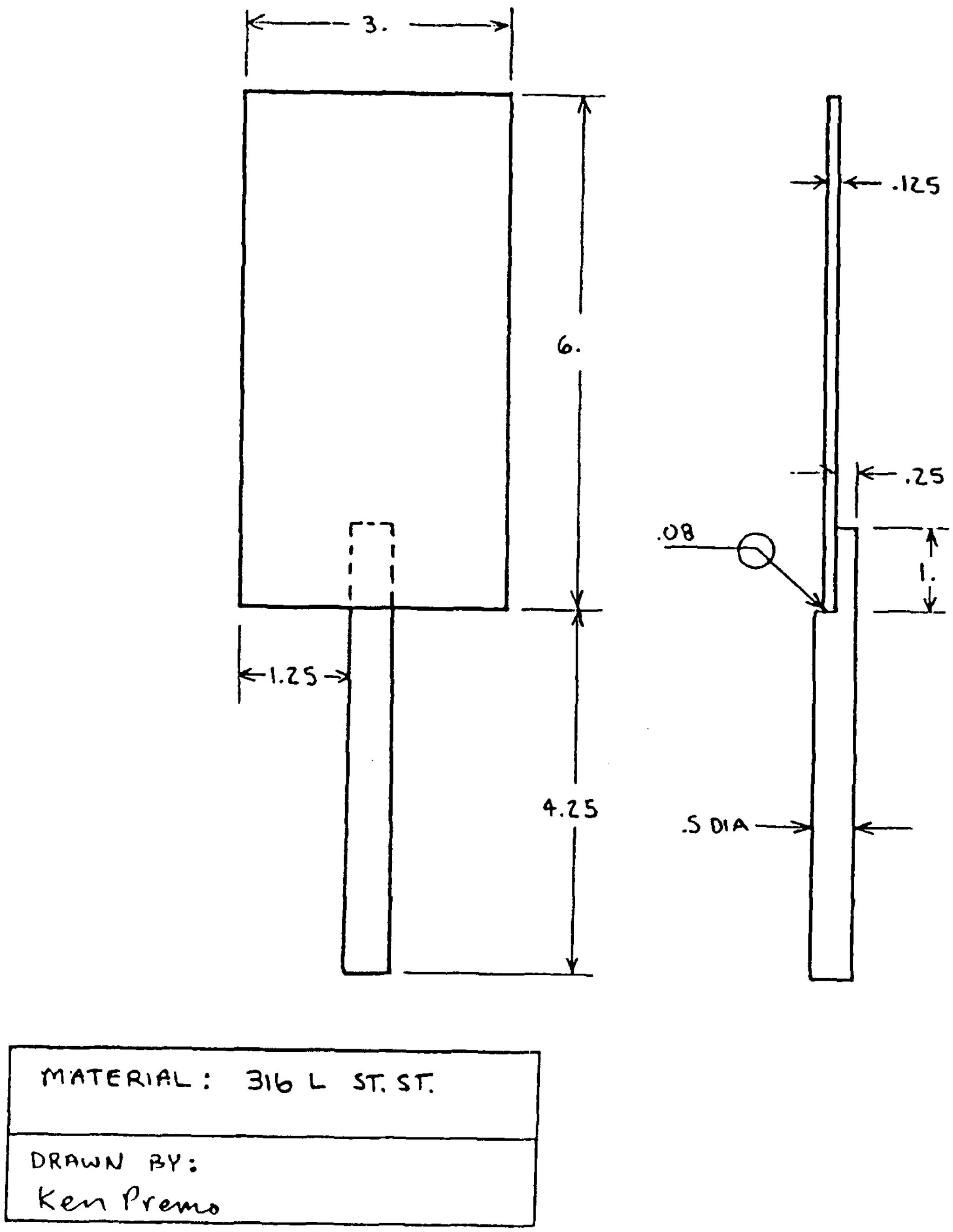


NOTE: INSTALL COVER TO HOUSING USING (4) 3/8" UNC ST ST NUTS.

DRAWN BY:	MATERIAL:
Ken Premo	316 L ST ST

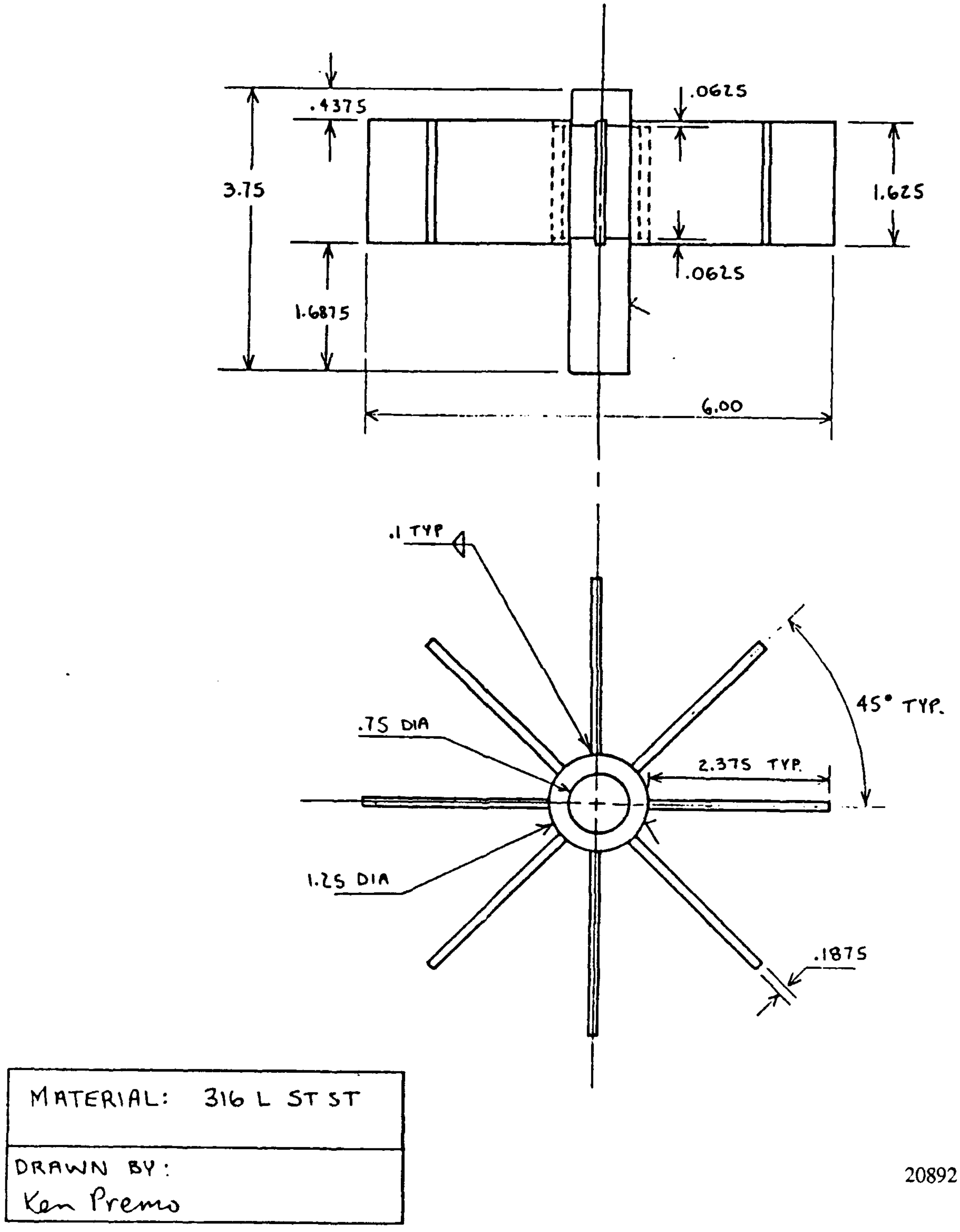
20904

HOUSING COVER
FIGURE 8.2-5



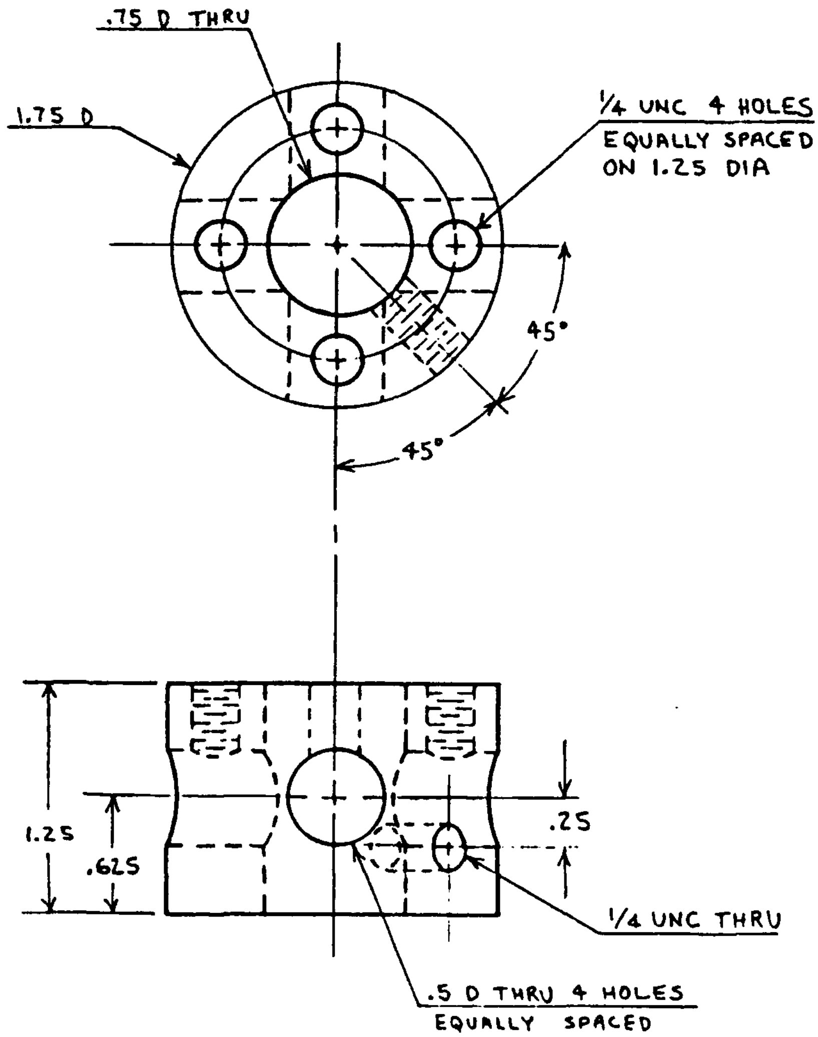
20905

PROPELLER BLADE (4 REQ'D)
FIGURE 8.2-6



20892

TURBINE WHEEL
FIGURE 8.2-7



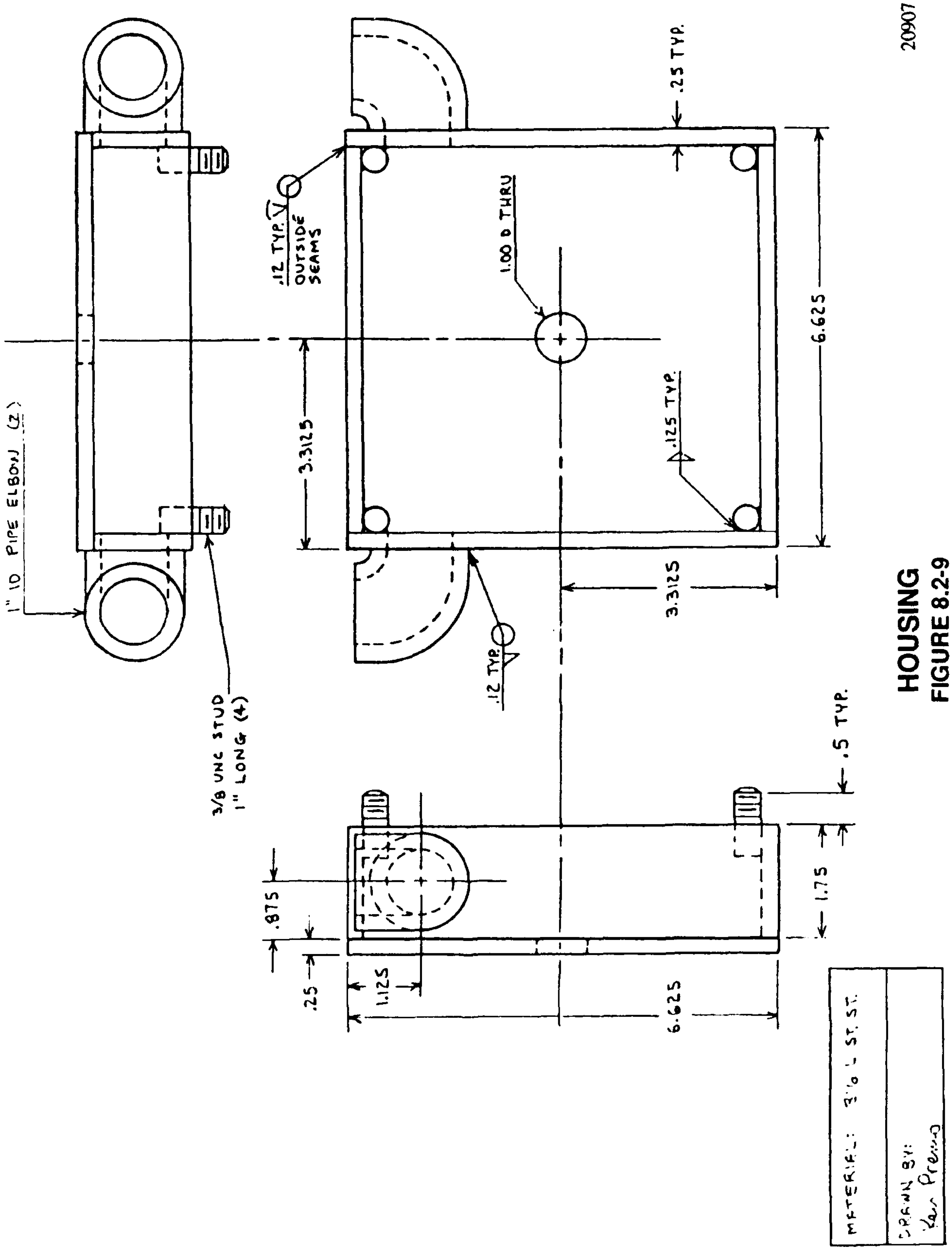
NOTE: INSTALL 1/4" UNC X 3/8" LONG SET SCREWS IN THREADED HOLES (5 REQ'D) SCREWS SHOULD BE ST. ST.

DRAWN BY:	MATERIAL:
Ken Preno	316 L ST ST

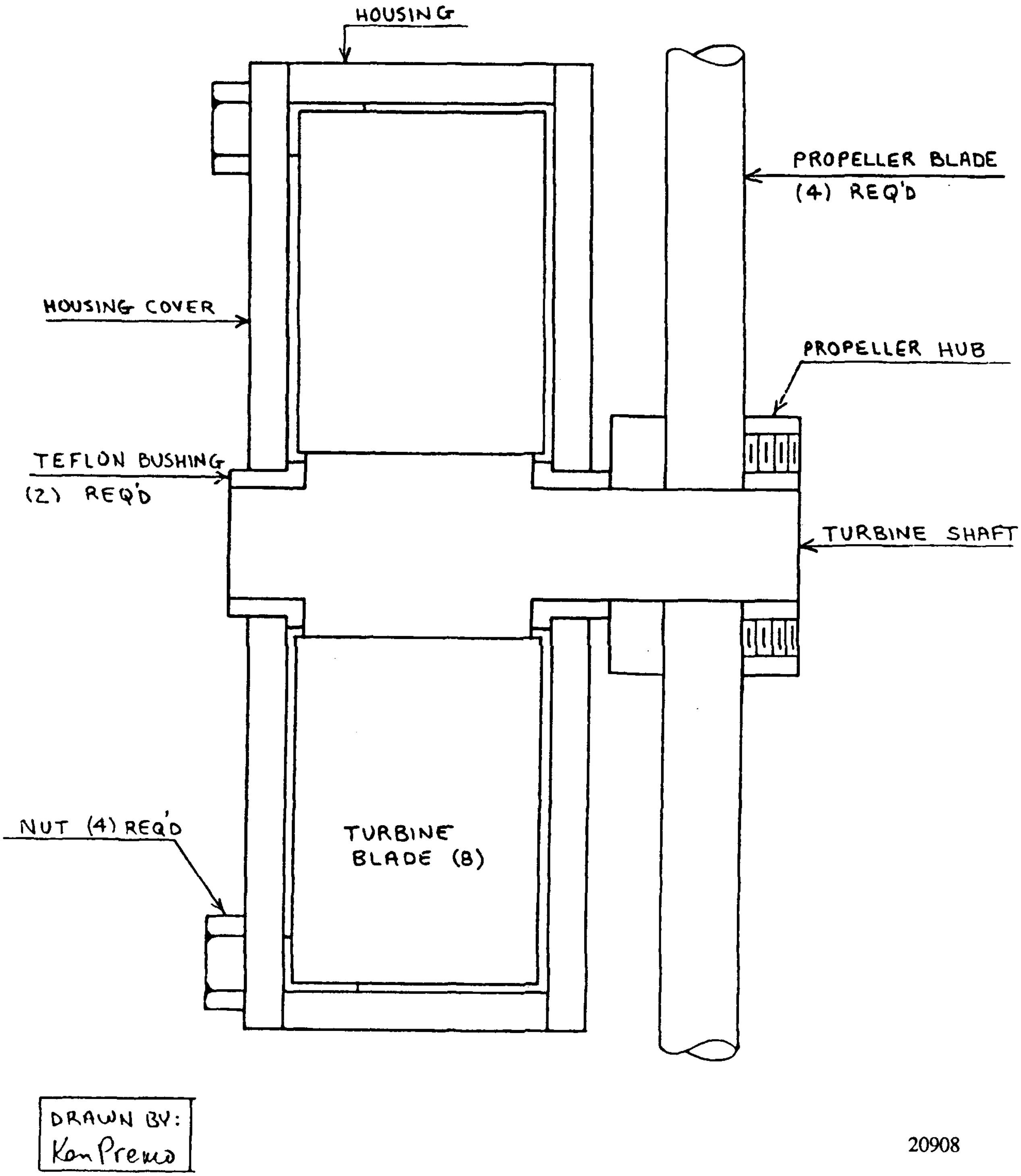
20906

PROPELLER HUB

FIGURE 8.2-8



HOUSING
FIGURE 8.2-9



ASSEMBLED VIEW OF TANK AGITATOR (SECTION THRU CENTER)
FIGURE 8.2-10

MAEPNC WIP Inventory Levels

Ave MAEPNC automatic line flow time = 26.7 hours. Thus, engines spend an average of 1 day in process in the automated cleaning line, out of each 30 day month.

1/30 x $8.385 million = $280,000 monthly MAEPNC WIP

WIP Reduction Values

Assuming a 30% reduction in WIP due to improved cleaning action:

$280,000 x 30%	=	$84,000/month.
$ 84,000 x 12 month	=	$1,008,000/year.

MDMSC estimates that the addition of the mechanical system described in this recommendation will reduce the MAE cost to maintain WIP inventories by $84,000 each month. Production figures for the T56 and TF39 engines are from the 3rd quarter of 1990 and were provided by MAE Scheduling. The engine unit costs are initial acquisition costs. The F100/200 engine workload was not included in this calculation as these engines are primarily hand cleaned and would not be affected by tank agitation.

Note: MDMSC has begun the patent research/application process for this device.

8.3 ELIMINATION OF TWO CLEANING LINES

As described in Paragraph 8.2.1.2 of the Task Order No. 14 CSR, MDMSC experiments with UDOS 2.0 show that Lines 1, 2, and 6 can be combined. The automatic line, in its current configuration, was designed to support the J79 engine workload, which has since been replaced by the F100/200 engine. As the F100/200 engines are primarily hand-cleaned, the automated line is now significantly under-utilized.

Lines 1, 2, and 6 use the same chemicals to support their cleaning processes and can be used to clean the same workloads. When the workloads of all three lines are combined, the effects on flow time/WIP levels are minute. This leads MDMSC to recommend that Lines 1, 2, and 6 be combined, allowing two tank lines to be eliminated. MDMSC estimates the floor space savings to be 1200 square feet per tank line, for a total of 2400 square feet. MDMSC recommends the addition of an 11th tank to Line 6 (containing rinse water) and the workloads of Line 1 and 2 be transferred to Line 6. This will free 2400 square feet at the outer edge of the tank area for other productive use. The cost of making this change should be included as part of the recommendation(s) for using the newly-available space.

APPENDIX A

LIST OF ACRONYMS AND ABBREVIATIONS

TASK ORDER NO. 14
PROCESS CHARACTERIZATION

LIST OF ACRONYMS AND ABBREVIATIONS

MDMSC	MCDONNELL DOUGLAS MISSILE SYSTEMS COMPANY
OC-ALC	OKLAHOMA CITY AIR LOGISTICS CENTER
SA-ALC	SAN ANTONIO AIR LOGISTICS CENTER
UDOS 2.0	UNIVERSAL DEPOT OVERHAUL SIMULATOR, VERSION 2.0
WIP	WORK IN PROCESS

END